FISCAL YEAR 1984 DEPARTMENT OF ENERGY AUTHORIZATION
(Conservation and Renewable Energy)

HEARINGS

BEFORE THE

SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

OF THE

COMMITTEE ON
SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

NINETY-EIGHTH CONGRESS

FIRST SESSION

MARCH 8, 9, 10, 15, 1983

[No. 10]

VOLUME II

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE
21-176 O WASHINGTON : 1983

H 701-65

COMMITTEE ON SCIENCE AND TECHNOLOGY

DON FUQUA, Florida, *Chairman*

ROBERT A. ROE, New Jersey
GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
MARILYN LLOYD, Tennessee
DOUG WALGREN, Pennsylvania
DAN GLICKMAN, Kansas
ALBERT GORE, Jr., Tennessee
ROBERT A. YOUNG, Missouri
HAROLD L. VOLKMER, Missouri
BILL NELSON, Florida
STAN LUNDINE, New York
RALPH M. HALL, Texas
DAVE McCURDY, Oklahoma
MERVYN M. DYMALLY, California
PAUL SIMON, Illinois
NORMAN Y. MINETA, California
RICHARD J. DURBIN, Illinois
MICHAEL A. ANDREWS, Texas
BUDDY MacKAY, Florida
TIM VALENTINE, North Carolina
HARRY M. REID, Nevada
ROBERT G. TORRICELLI, New Jersey
FREDERICK C. BOUCHER, Virginia

LARRY WINN, Jr., Kansas
MANUEL LUJAN, Jr., New Mexico
ROBERT S. WALKER, Pennsylvania
WILLIAM CARNEY, New York
F. JAMES SENSENBRENNER, Jr., Wisconsin
JUDD GREGG, New Hampshire
RAYMOND J. McGRATH, New York
JOE SKEEN, New Mexico
CLAUDINE SCHNEIDER, Rhode Island
BILL LOWERY, California
ROD CHANDLER, Washington
HERBERT H. BATEMAN, Virginia
SHERWOOD L. BOEHLERT, New York
ALFRED A. McCANDLESS, California
TOM LEWIS, Florida

J. H. Poore, *Executive Director*
Robert C. Ketcham, *General Counsel*
Regina A. Davis, *Administrator*
David S. Jeffery, *Minority Staff Director*

Subcommittee on Energy Development and Applications

DON FUQUA, Florida, *Chairman*

RICHARD L. OTTINGER, New York
TOM HARKIN, Iowa
RALPH M. HALL, Texas
PAUL SIMON, Illinois
RICHARD J. DURBIN, Illinois
FREDERICK C. BOUCHER, Virginia
ROBERT A. ROE, New Jersey
JAMES H. SCHEUER, New York
MARILYN LLOYD, Tennessee
ROBERT A. YOUNG, Missouri
BILL NELSON, Florida
DAVE McCURDY, Oklahoma
NORMAN Y. MINETA, California

F. JAMES SENSENBRENNER, Jr., Wisconsin
CLAUDINE SCHNEIDER, Rhode Island
BILL LOWERY, California
HERBERT H. BATEMAN, Virginia
TOM LEWIS, Florida
WILLIAM CARNEY, New York
JUDD GREGG, New Hampshire

CONTENTS

WITNESSES

March 8, 1983:

Page

Jan W. Mares, Assistant Secretary for Fossil Energy, Department of Energy; accompanied by Donald Bauer, Deputy Assistant Secretary for Fossil Energy; and Jerry Walsh, Deputy Assistant Secretary for Management 2

Joseph Tribble, Assistant Secretary for Conservation and Renewable Energy, Department of Energy; accompanied by Dr. Robert San Martin, Deputy Assistant Secretary for Renewable Energy; and Dr. Melvin Chiogioji, office director, State and local assistance programs 234

March 9, 1983:

Dr. Ivan L. Bennett, Vice Chairman, Energy Research Advisory Board on the Federal Role in Solar and Conservation Research and Development 319

Victoria Tschinkel, Chairman, Energy Research Advisory Board, Solar R&D Panel 341

Grant P. Thompson, Chairman, Conservation Panel of the Energy Research Advisory Board 355

Dr. David L. Morrison, president, Illinois Institute of Technology Research, Chicago, Ill 448

Dr. Richard Rowberg, Energy Program Manager, Office of Technology Assessment 463

March 10, 1983:

Thomas Vonier, Thomas Vonier, Associates, Inc., Washington, D. C 483

Frank Kensill, Institute for Human Development, Philadelphia, Pa 499

Donald G. Carter, Carter Engineering, Inc., Silver Spring, Md 511

Thomas J. Wilbanks, Associate Director, Energy Division, Oak Ridge National Laboratory, Oak Ridge, Tenn 531

Bradford Chase, acting under secretary for energy, office of policy and management, State of Connecticut 548

Craig Marks, executive director, environmental activities staff, General Motors Technical Center, Warren, Mich 573

March 15, 1983:

Dr. Lawrence Papay, vice president, Southern California Edison Co 584

Byron J. Washom, president, Avanco Corp.; and vice chairman, solar thermal division, Solar Energy Industries Association 600

B. J. Tharpe, general manager, advanced energy programs department, General Electric Co 662

Arthur Jackson, director, wind energy systems, Hamilton Standard Division, United Technologies Corp. 672

Dr. Leslie S. Levine, vice president, Biomass Energy Research Association; and director of advanced technology, JAYCOR 696

Dr. Patrick K. Takahashi, associate director, Hawaii Natural Energy Institute, University of Hawaii 717

Dr. Charles W. Berge, executive vice president, Grace Geothermal Corp 731

1984 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 8, 1983

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:37 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Nelson, Boucher, Sensenbrenner, Carney, Lewis, Bateman, Lowery, Schneider, and Gregg.

Mr. **Fuqua**. The subcommittee will be in order.

We begin today the first in a series of hearings on the Department of Energy's fossil, conservation, and renewable energy programs.

This year we are again presented with a budget for fiscal year 1984 that calls for substantial cuts in those programs. Conservation would be cut by approximately 75 percent; solar and other renewables by 60 percent; fossil energy by about 56 percent.

Once again we have to determine whether these cuts are justified; whether the free market will pick up the research that is being dropped by the Government; and whether an energy R&D program that devotes less than 15 percent of its energy budget to nonnuclear energy in fact is in the Nation's interest.

It is clear that these requests do not provide the sense of balance to the Nation's energy efforts that our committee has constantly supported.

I was pleased when Secretary Hodel testified in the hearings, and I quote from his testimony. He said the administration "seeks a balanced energy program that includes a full range of energy technologies." He also went on to state that the goal of the Department was to "foster the development and utilization of a wide range of energy resources including conservation, solar and other renewables."

So it appears that it is up to Congress once again to make the Secretary's 1984 budget more consistent with the stated goals and objectives.

Before introducing our witnesses for today, I would ask unanimous consent that an opening statement by the Honorable F. James Sensenbrenner be placed in the record at this point.

[The opening statement of Mr. Sensenbrenner follows:]

Opening Statement of Hon. F. James Sensenbrenner, Jr.

Thank you for this opportunity to extend a welcome to Mr. Tribble, the Assistant Secretary for Conservation and Renewable Energy, and Mr. Mares, the Assistant Secretary for Fossil Energy.

We look forward to their testimony today on the research programs conducted by their offices. These programs include solar, geothermal, fossil, and conservation-related activities.

The Administration has proposed significant reductions in these programs for fiscal year 1984. These reductions are premised upon the Administration's commitment to fund only those research programs that may be termed "long-term, high-risk" activities that the private sector is unable to fund. While I share their underlying commitment, due to this country's economic condition, I am concerned that some of the programs are being turned over prematurely to the private sector.

Further, I am concerned about the balance within the Department of Energy's research programs, of competing energy technologies.

I look forward to your explanation of the fiscal year 1984 budget for these programs.

Mr. **Fuqua**. We are pleased today to have once again Mr. Jan Mares, the Assistant Secretary for Fossil Energy.

He will be followed by Mr. Joe Tribble.

We will now hear from Mr. Mares.

[For additional testimony on fossil energy, see vol. III of fiscal year 1984 Department of Energy authorization hearings.]

STATEMENT OF JAN W. MARES, ASSISTANT SECRETARY FOR FOSSIL ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DONALD BAUER, DEPUTY ASSISTANT SECRETARY FOR FOSSIL ENERGY; AND JERRY WALSH, DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT

Mr. **Mares**. Thank you, Mr. Chairman.

Good morning, Mr. Chairman and members of the committee.

I recognize that the committee has a number of topics to cover this morning, so I will not occupy a disproportionate amount of the time with my opening remarks.

As you have said, Mr. Chairman, we have provided——

Mr. **Fuqua**. Do you have a statement you would like to make part of the record?

Mr. **Mares**. We have a detailed statement that we have provided, and I have an overall summary that takes about 8 minutes to read, and I would prefer to do that.

Mr. **Fuqua**. That would be fine.

Mr. **Mares**. Thank you.

My principal deputy, Mr. Donald Bauer, and my Deputy Assistant for Management, Mr. Jerry Walsh, are seated with me at the table. As is customary, we have key members of the fossil energy staff here that would be able to answer questions if you need more detail.

To summarize our budget request, Mr. Chairman, let me echo two points that Secretary Hodel stressed in his appearance before you earlier this year, February 8.

First, comparing this budget request with the one of a year ago indicates some important trends. In fossil energy, the funds we are requesting for 1984, $138 million, representing an increase of 29 percent over the request we made a year ago.

I would also like to make the same statement Secretary Hodel has made. We are well aware that this committee—and Congress as a whole—recommended and appropriated considerably more in 1983 than our request. However, we are attempting to suggest that there is a trend within the entire Department of Energy budget to provide a better balance of R&D priorities.

The second point I want to stress is that we are prepared to work with the committees in reaching an early consensus of what our funding priorities should be. One of the first things that Secretary Hodel stressed when he joined the Department was that for too long we as a Nation have torn ourselves apart over energy issues: Do we need more or less? In this form or that? The debate has extended as well into the R&D aspects of energy.

We wholeheartedly support the President's commitment to reduce budget deficits through tighter reins on Federal spending. But, within the context of our proposed funding levels, we are prepared to work with this committee to achieve another core commitment—a bipartisan consensus on the mix of scientific and technological activity that would be most productive for this Nation. This is critical if we are to make the most efficient and effective use of the dollars that are entrusted to the Federal Government by the taxpayer.

As a starting point for our specific discussions of the fossil energy budget, I would like to refer the committee to the chart that we have here, which is also reproduced in my prepared statement. This is the fundamental basis of our budget. As you can see, it depicts the typical path a new technology takes from test tube to commercial reality. It gives some sense of the relative expenditures that are spent at various stages.

The emphasis of our program this year, as it was last year, is on the basic science and applied research, not on the commercialization or on the process development.

The basic science is the development of the scientific knowledge, including a fundamental understanding of the physical and chemical properties of fossil fuels.

Applied research takes us into the broad engineering and physical science aspects of specific fossil technologies. At this point, we gain a better understanding of processes, applications, or systems, although the practical utility may not yet be proven.

Proof of concept is where the technical viability of an energy concept is established. Here one learns enough to establish the basic engineering feasibility of a concept and to forecast its expected economic and environmental performance standards.

These are the factors that permit industry to make the subsequent decisions on whether the concept merits further process development and eventual commercialization.

I am aware, as are you, that milestones for technology development do not always fit into neat, compartmentalized boxes as we have indicated on this chart. But the point of visualizing the evolution of technology in this manner is to emphasize that the focus of the Federal program is most importantly on those generic aspects of research and development. When you move too far to the right, to the process development and the commercialization, the Government runs the risk of inserting itself into the selection of one process over another.

At these more advanced levels of technological maturity, the decisions are governed by a host of complex market-driven analyses and projections—factors historically not within the expertise of the Government.

In the past, when the Government did insert itself as a decisionmaker in these stages, it sometimes made the correct choice and picked the right technical concept to pursue. But I am convinced there have been many times when Government's involvement in the process development and commercialization stages of R&D has disadvantaged privately financed competing concepts, some of which might ultimately have had better potential.

In these times of budget deficits, a Federal dollar spent in these latter stages of R&D has a double impact: It not only takes a dollar out of private capital funds, but it may also preclude a dollar from being spent by a commercial firm developing a competing process.

Therefore, the budget we have put together emphasizes generic research and development; that is, R&D which may have a substantial payoff but the benefits of which, at the present stage of research, are not specific to an individual company.

The limitations on a firm's ability to capture the rewards of innovation in this area, which is in the basic science, the applied research, and some in the proof of concept, limit the amount of R&D that a private enterprise is willing to undertake.

It is here, therefore, where the public funding is appropriate, and it is in these first two stages, particularly in the applied research area, where the fossil energy program proposes to concentrate its funding in fiscal year 1984.

On page 3 of my prepared statement, I have indicated the relative priorities that we used to determine our funding levels within fossil energy. As last year, our strategy gives the highest priority to establishing the technical data bases that will enable industry to develop new sources of liquid fuels and substitutes for petroleum.

These priority programs include our enhanced oil recovery oil shale, coal liquefaction, and those aspects of gasification which are critical to liquefaction, and technologies that will enable coal to be substituted for oil in utility and industrial applications.

Together, the program elements that make up this priority account for more than 60 percent of the $138 million budget request we are making.

Gaseous fuel technologies, particularly where gas can substitute for liquid fuels, comprise another high priority area, as does the fostering of improved concepts for increasing the economic and environmental performance of coal and other fossil energy technologies.

And, consistent with the administration's commitment to fundamental science and technology, we are maintaining significant levels of effort in our advanced research and technology development program in coal and its analog in petroleum and gas, the advanced process technology program.

In the interest of time, I will not go into detail on the individual budget levels proposed for each of these elements—they are included in the detailed statement—but I would like to conclude by mentioning briefly two actions regarding the fossil energy field structure.

First, we are making progress in the transfer of our three western energy technology centers to non-Federal operation. On February 28, I signed, along with President Thomas Clifford of the University of North Dakota, an agreement signifying the transfer of the Grand Forks Energy Technology Center to the university effective April 1. We anticipate similar action to be taken later this month between the University of Wyoming and our Laramie Energy Technology Center.

In the case of the Bartlesville center, we have extended the due date for receiving bids until March 18, and I am confident we will have a number of high-quality proposals to operate that center for the Federal Government that the Source Evaluation Board would then evaluate.

In all of these cases, I would like to reemphasize my continued belief that the transfer of these centers to operation either by universities or a non-Federal operator will lead to a significant expansion of their usefulness to this country. They have more to offer than we have the capability to support in the near future. Permitting them to expand their productivity beyond that which can be funded only by the Department of Energy will not only be in their best interests but in the best interests of the country as a whole.

The final point I would like to make, Mr. Chairman, is more a matter of bookkeeping. In the fiscal year 1983 budget, Congress directed the Department to separate the management and administrative costs for the technology centers—the so-called indirect costs—from the direct program costs. We were too far along in the budget formulation process for fiscal year 1984 when the direction was given to identify these costs as a separate line item. Consequently, we have recently provided to this committee a breakdown of the estimated $33 million in ETC program direction costs that are part of the $138 million overall request.

Mr. Chairman, in summary, we believe this budget is responsive to the twin challenges before us: First, to continue the necessary restraints on Federal spending, while, second, establishing a sound base of technological understanding that will be needed by future generations.

We believe Government can play a useful role that will complement, rather than compete with, the private sector. And we believe this budget proposal represents a realistic approach toward fostering the type of consensus that will permit a sustained core level of effective R&D in the fossil energy area to continue.

Thank you, Mr. Chairman. I would be happy to respond to your questions.

[The prepared statement, plus answers to questions asked of Mr. Mares, follows:]

STATEMENT OF JAN W. MARES
ASSISTANT SECRETARY FOR FOSSIL ENERGY
U.S. DEPARTMENT OF ENERGY
BEFORE THE
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
MARCH 8, 1983

Mr. Chairman and Members of the Committee:

The Fiscal Year 1984 Fossil Energy budget request continues the transition begun in 1982 from a technology program that emphasized large, process-specific pilot and demonstration facilities to one that is now concentrated on more generic basic and applied research.

The Nation is fortunate to have abundant fossil energy resources. Our deposits of coal, petroleum, oil shale, tar sands, and natural gas exceed the known fossil energy resources of any other nation. Still, diverse and extensive advances are needed in our scientific and engineering knowledge base to use these resources effectively. Much of the needed process development and commercialization of new technologies will come from the industrial sector in response to market incentives. To support these private initiatives, we continue to view the creation of a fundamentally sound knowledge base as an appropriate and important role for the Federal Government.

The FY 1984 budget request of $138 million for Fossil Energy research and development represents the Administration's effort to fashion a sound, core program that will continue to produce the technological information the Nation will need in order to develop and deploy advanced energy options. Still, it is a request that has been developed within the framework of the serious budget deficit problems that confront us as a Nation.

The Economic Context of the FY 1984 Budget Request

The energy-related R&D portions of the Department of Energy budget, and thus the Fossil Energy component, are part of the Federal government's non-defense discretionary programs. The President has emphasized the need for a freeze on the aggregate of these programs in FY 1984 relative to the 1983 appropriations. This is an integral part of the goal to reduce the structural deficit, and it is reflected in the overall Administration budget proposals. Within the aggregate of non-defense discretionary programs, however, there are obviously some increases and decreases.

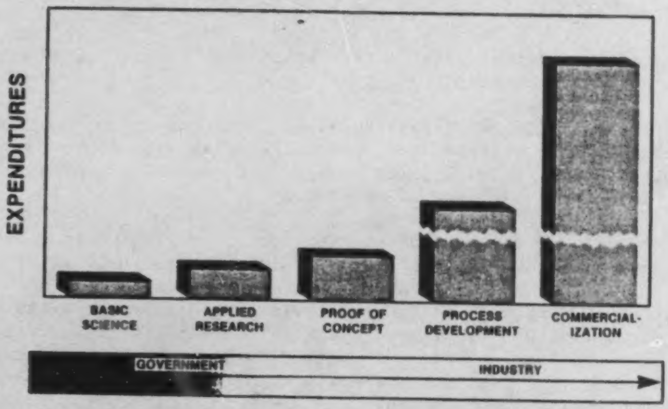
In developing the FY 1984 budget, the Administration, the Department of Energy, and the Office of Fossil Energy have evaluated many requests and potential uses for government funds that are neither possible nor appropriate within the context of the President's economic and energy programs. In selecting the research projects included in our budget, we have focused on those elements that attract little or no private funding. The risks, costs, or payoffs are either too long-range or uncertain, or the benefits are not specific to the private funder.

The FY 1984 budget request for Fossil Energy R&D represents a 29 percent increase over the Administration's request in FY 1983. While this is admittedly much less than the $311 million appropriated in FY 1983, it reflects an effort to work with the Congress in developing the most appropriate mix of programs. Within the context of a very fiscally constrained year, we believe we are presenting to the Nation a rational, balanced and adequate Federal budget for Fossil Energy research.

The FY 1984 Fossil Energy Strategy and Priorities

If the U.S. is to continue to maintain its technological leadership in energy, systematic advances must occur in all stages of the research, development and commercialization cycle -- from basic science to applied research, proof-of-concept, process development, and finally to commercialization. These steps are shown graphically in the following chart:

TECHNOLOGY DEVELOPMENT PATH



The latter stages of this development path are the most costly, and this is where extensive private sector investments have occurred in the past and will continue to be required in the future.

The earlier stages, through proof-of-concept, feed the private sector R&D investment pipeline. While the projects in these earlier stages may have a very high benefit/cost ratio from a national perspective, private sector investment is often limited or nonexistent. The ultimate benefits of these early stages of research may be quite large, yet they are frequently difficult to predict, highly risky, or long-term, or cannot be captured by private firms. Thus, there is a valid Federal role to provide front-end R&D support in a diversified spectrum of fossil fuel technologies.

The Department of Energy's FY 1984 budget, therefore, is oriented principally toward the applied research portion of the technology development path, with some effort also in the basic science and the "proof-of-concept" stages. Because the Federal role is focused on these more generic aspects of R&D, private industry is thus able to select those technologies warranting scale-up with its own funds without governmental bias or interference.

Fossil Energy Priorities

Recognizing the prospects of a continued domestic reliance on liquid fuels, the Fossil Energy strategy gives high priority to establishing data bases that will enable industry to develop new sources of liquid fuel supplies and petroleum substitutes with acceptable environmental impacts. This priority includes:

- advanced technologies for recovering oil from large, currently unrecoverable petroleum resources;
- advanced concepts for producing oil from shale and tar sands, and from coal via direct and indirect liquefaction;
- those aspects of coal gasification which are critical to advanced liquefaction processes;
- advanced technologies (including aspects of combustion, control technology, heat engines, and fuel cells) that substitute coal for oil in utility and industrial applications where conventional coal-fired technology is now precluded.

More than 60 percent of the $138 million requested for Fossil Energy R&D relates specifically to the "liquids" and "liquids displacement" priorities.

The Fossil Energy strategy recognizes several other high priority areas. Gaseous fuels can substitute for liquid fuels in many applications. Unconventional gas resources can provide this Nation an abundance of new gaseous fuel supplies if today's scientific and engineering knowledge can be expanded for associated extraction technologies.

Another high priority deals with establishing the scientific and engineering foundations for the use of coal and other abundant fossil energy resources through improved technologies. Inherent in the technologies being pursued in this priority is the potential for large payoffs in improved economic and environmental performance, increased efficiency, and greater flexibility of coal use. This priority includes aspects of control technology, combustion systems, and fuel cells. Also within the Fossil Energy priorities are generic and crosscutting research that can contribute to economically efficient energy production in the future.

All of the R&D conducted within the Fossil Energy program is coupled with appropriate environmental research. Specifically, we are working to establish data bases that will help industry mitigate and resolve problems rather than merely expand the range of questions and concerns. Potential impacts are characterized within our program, and the performance of new and developmental systems for controlling these impacts are evaluated. In this way, cost beneficial solutions to environmental concerns will be available on a schedule consistent with the progress of technology development.

The FY 1984 Fossil Energy Budget Request

The FY 1984 Fossil Energy budget request is made up of three major components:

	FY 1984 Budget Authority
Coal	$ 109.45 million
Petroleum	23.35 million
Gas	5.20 million
Total	$ 138.00 million

Within the $138 million request, the Administration is requesting $94 million of new budget authority. The remaining $44 million is available from prior year budgets, as shown below, and would be applied to the 1984 program.

Appropriation Transfer from Alternate Fuels Production Program (P.L. 96-126)	$ 13 million
Prior Year Offset	$ 31 million

The $13 million is derived from unexpended funds from the Alternative Fuel feasibility studies and cooperative agreements program authorized by Congress in 1979. A total of $31 million remains unobligated from Fossil Energy R&D budgets prior to FY 1983, including funds from the gasification demonstration plant projects (construction and operating expenses), the Solvent-Refined-Coal II demonstration project (construction and operating funds), the Pittsburgh Energy Technology Center Program Support building (construction funds), and the Program Direction (Headquarters) budget.

As the Committee is aware, P.L. 97-257 transferred the coal mining research and development program to the Bureau of Mines in the Department of Interior; therefore no funds are requested in the FY 1984 Fossil Energy R&D budget for Mining R&D.

The major budget categories of the FY 1984 request are described as follows:

COAL

COAL LIQUEFACTION

(Budget Authority In Millions)

FY 1982	FY 1983	FY 1984 Request
$ 98.8	$ 37.6	$ 17.0

The goal of the Coal Liquefaction program is to contribute to a data base that will facilitate the private sector's development of improved coal conversion processes. Products obtained from coal liquefaction can replace petroleum products as boiler fuel for utilities or can be refined to transportation fuel, furnace oils, and chemical feedstocks. Coal is, by far, the largest domestic fossil energy resource available to the U.S., and it is anticipated to be utilized eventually as a feedstock to increase the supply of liquid fuels.

An industry based on indirect liquefaction -- where coal is first gasified, then converted into liquid products -- could be initiated using commercially demonstrated process steps based, in large degree, on foreign technology. At the present state of development, however, indirect liquefaction processs are high cost and have relatively low thermal efficiencies. These processes could be improved if advanced, more efficient gasifiers, many of which are now becoming commercially available, are employed. These gasifiers, however, produce a syngas with a relatively low hydrogen content. Therefore, the DOE indirect liquefaction program is developing improved syngas conversion processes that are capable of functioning effectively using low-hydrogen content syngas.

Direct liquefaction promises lower costs and improved thermal efficiencies. The technical viability of a limited number of direct liquefaction processes has been demonstrated (Exxon Donor Solvent, H-Coal, Solvent-Refined-Coal) but commercial application has not yet occurred. New advances in catalysts and in the multi-stage direct liquefaction approach may improve the future commercial prospects of this technology.

FY 1984 Budget ($ in millions)

o Indirect Liquefaction	$ 4.0

- — Complete funding of fluid bed methanol-to-gasoline project with the Federal Republic of Germany.
- — Continue bench scale research into new catalyst systems and process concepts.

(continues on next page)

- Advanced Process Development ....$ 9.0
  (direct liquefaction)
  - Continue bench scale R&D in catalyst development and improved process concepts.
  - Continue bench scale R&D in integrated two-stage liquefaction (ITSL).
- Support Studies/Engineering Evaluations ....$ 4.0
  - Continue engineering evaluations and component research.
  - Continue health effects and data base management activities.

SURFACE COAL GASIFICATION

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$54.2	$39.0	$16.9

By means of gasification, coal can be used for the economic production of gases having heating values that range from low/medium-Btu gas for industrial and electric utility uses to high-Btu gas of pipeline quality that can be used to supplement supplies of natural gas. Gasification technology can also be used to produce a synthesis gas suitable for subsequent conversion into a variety of liquid fuels or for use as a feedstock for the manufacture of chemicals. This flexibility in the conversion of coal into alternate forms of clean energy is being acquired through the development of advanced gasifiers and gasification processes that have the capability to utilize a wide range of U.S. coals having widely differing physical properties and chemical compositions that characterize these heterogeneous feedstocks.

In FY 1983, the major gasification process development units and pilot plant projects will be completed, including the BiGas concept for converting coal into a substitute natural gas and the agglomerating pressurized fluidized bed gasifier technology for the production of low and medium-Btu gas. Therefore, the proposed FY 1984 budget would continue to redirect the program from the development of specific gasifier concepts to the investigation of more generic gasification systems.

Emphasis will be placed on improving the understanding of the entrained and fluidized bed gasification concepts, using small units at the Morgantown Energy Technology Center and cold flow models. Work will also continue on increasing today's knowledge base for advanced carbonization-type reactors operating on a variety of coals over a broad range of operating conditions. Studies of the characteristic effluents from certain gasifiers will be conducted, and advanced cleanup components and systems as well as a novel dirty gas heat exchanger concept will be evaluated. Research will also be done to improve the materials and designs of critical components in coal gasification systems, such as heat exchangers, expanders, compressors, and valves.

The FY 1984 budget would also provide sufficient funds to continue monitoring the Great Plains coal gasification project in North Dakota, construction of which is nearly 40 percent complete and progressing toward a planned December 1984 target date for full gas production.

FY 1984 Budget ($ in millions)

o Advanced Process Development	$ 4.0
- Continue tests on small entrained-bed and fluidized-bed reactor systems to understand parameters that must be controlled to successfully operate advanced gasifiers. - Conduct basic experiments on advanced waste water treatment processes.	
o Systems Engineering Concepts	$ 6.9
- Continue support of key gasifier data base studies essential to technology transfer and advancing state-of-the-art. - Continue efforts to resolve state-of-the-art instrument and equipment problems and to increase gasifier systems reliability.	
o Environmental and Engineering Analyses	$ 3.0
- Continue only high priority projects having potential to provide solutions to problems identified as being technology limiting. - Continue efforts to determine the capabilities and limitations of cleanup systems and the environmental impact of zero waste discharge requirements.	
o Great Plains Project	$ 3.0
- Continue project monitoring and management activities.	

UNDERGROUND COAL GASIFICATION

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$8.3	$6.0	$2.0

Underground Coal Gasification (UCG) is an unconventional method to produce fuels by gasifying seams of coal "in situ" without mining. Underground coal gasification can convert solid coal underground to more easily recovered gaseous products that can either be directly utilized or converted to a suite of hydrocarbon products. Successful adoption of these processes could quadruple U.S. coal reserves while providing fuels at potentially lower costs and with less adverse environmental impacts than other synthetic fuels options. The expected final products using gas generated by this technology could be transportation fuels (primarily methanol and gasoline), electric power, industrial heating, synthetic natural gas, chemical feedstocks, and in site specific cases, CO_2 for enhanced oil recovery and hydrogen for refinery use or shale oil upgrading.

The FY 1984 budget would continue the development of a promising new concept in underground coal gasification, the Controlled Retracting Injection Point (CRIP) process. The basic concept of the CRIP system is to keep the burn zone growing in the upstream direction by cutting off or perforating the air or oxygen/steam injection pipe at successive new locations at the base of the coal. There is strong evidence that maintaining the injection point at a low position in the coal seam is essential for obtaining good gas quality and high resource recovery.

FY 1984 Budget ($ in millions)

- o Environmental and Advanced Research .... $ 2.0
  - Continue post burn environmental research and monitoring.
  - Complete cost shared proof-of-concept test of Controlled Retracting Injection Point (CRIP) concept.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$56.3	$36.0	$30.5

The Advanced Research and Technology Development (AR&TD) activity plays an important role in the Department's Fossil Energy program through development of the technology base in coal. Basic, applied, and exploratory high risk, potentially high payoff research at the Energy Technology Centers and National Laboratories, universities and industrial laboratories helps extend the fundamental scientific and engineering knowledge base providing ideas for new processes and technical breakthroughs in coal conversion and utilization.

FY 1984 Budget ($ in Millions)

- o Direct Utilization .... $ 4.8
  - Continue coal combustion research.
  - Continue generic research in coal cleaning and control technology.
  - Continue research related to improving combustion processes for fluidized-bed technology.

- o Materials and Components .... $ 6.5
  - Continue research in the areas of high temperature corrosion, slag refractory interactions, structural ceramics, hydrogen effects, and erosion wear.
  - Continue research into novel heat exchanger concepts.
  - Continue research on novel, advanced "dirty gas" valve concepts such as power fluidics, and multiple orifices.
  - Continue efforts on slurry pumps and critical subsystems such as check valves, seals, and materials for stuffing boxes.

(continued on next page)

o Processes	$7.0

- Continue research, principally at ETC's, on low rank coal liquefaction, development of analytical techniques and reaction chemistry.
- Conduct research on advanced liquefaction concepts.
- Continue research on catalysis and kinetics, structure and reactivity of coal, properties of coal, properties of coal liquids, and liquefaction of synthesis gas.
- Continue research on coal conversion fundamentals to generate data needed to advance the state-of-the-art of gasification to the next generation of development.
- Continue research along a broad technical front involving kinetics, thermodynamics, catalytic mechanisms, modeling, hydrogasification, pyrolysis, fluidization studies, acid gas removal, hot gas cleanup, gas separation, conversion studies and novel concepts of gas generation by reaction of coal with steam, air and oxygen.
- Continue basic studies on the relationships of coal and components and coal behavior during gasification.

o Program Development and Coordination	$ 1.7

- Perform crosscutting support for policy development, R&D assessment and environmental, safety and health compliance overview for Fossil Energy. ($1.0)
- Continue overall planning and policy development for Fossil Energy. ($0.7)

o University Coal Research	$ 4.0

- Initiate or renew approximately 25 university projects directed at improving the fundamental scientific and technical understanding of the chemical and physical processes involved in the conversion and utilization of coal.

o Construction	$ 5.0

- General Plant projects. ($2.0)
- Wastewater treatment facility, METC. ($2.0)
- Surface water containment facility, PETC. ($1.0)

o Capital Equipment	$ 1.5

- Provides for necessary capital equipment at ETC's and National Laboratories.

CONTROL TECHNOLOGY AND COAL PREPARATION

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984
$ 25.2	$ 27.9	$ 17.1

The purpose of the Control Technology and Coal Preparation program is to help private industry develop advanced technologies necessary to maximize environmental quality and minimize the cost of energy used by coal-fired utilities and industry. Current efforts concentrate on coal preparation, flue gas cleanup, and gas stream cleanup.

The current program is an outgrowth of research begun in FY 1979 to develop new, advanced concepts for environmental control technology, specifically in flue gas and gas stream cleaning. In FY 1983, the coal preparation R&D work was transferred from the mining program. This permitted a comprehensive program to be developed in Control Technology Systems that includes all aspects of cleanup R&D, from precombustion (coal preparation) to in-process (gas stream cleanup) through post-combustion (flue gas cleaning and waste management).

The objective of the coal preparation activity is to develop technologies which can remove sufficient quantities of ash and sulfur from coal so that coal can be substituted for oil and natural gas in many applications. In FY 1983, laboratory research will be completed on two advanced concepts -- fused salt desulfurization and microwave processing. Both have the potential for reducing the sulfur and ash in coal to levels comparable to fuel oil. Laboratory evaluations of the high gradient magnetic separation process will also be completed. This technique is effective in removing inorganic sulfur (occuring as pyrite) and ash from finely-ground coal. Testing of the two-stage froth flotation technology to extract minerals and pyrites from coal will also be concluded in FY 1983.

With these activities concluding in FY 1983, the FY 1984 coal preparation program will focus on evaluating the critical engineering design and performance issues in the areas of: physical cleaning of fine coal; comminution (size reduction) and fine coal dewatering and consolidation; chemical cleaning; and dewatering and beneficiation of low rank coals and lignites.

Flue gas cleanup activities were significantly reoriented in FY 1983 to concentrate on technologies that remove nitrogen oxides (NO_x), sulfur oxides (SO_x), and in some cases, particulates, simultaneously rather than in multiple cleanup steps. A "proof-of-concept" unit for the E-beam (electron beam)/lime flue gas cleanup concept will be completed in FY 1983, and testing will begin. Construction of a "proof of concept" unit for a similar concept, which would substitute ammonia for the lime in an E-Beam system, will begin in FY 1983, with testing scheduled for 1984. Studies were begun in FY 1983 on several innovative concepts for simultaneous NO_x/SO_x removal systems, and in FY 1984, one of these concepts will be evaluated at bench scale.

In the gas stream cleanup program, proof-of-concept testing will be completed in FY 1983 on an electrostatic precipitator specially designed for controlling particulates from a pressurized fluidized bed combustor, and bench scale evaluations will begin of selected advanced particulate control systems. Evaluations of a zinc ferrite desulfurization process capable of operating in the temperature range of a fluid-bed coal gasifier will be conducted in FY 1983, and in FY 1984, the process will be linked with a gasifier for testing.

Funding for sampling and characterizing coal derived wastes will be completed in FY 1983, with some contractual efforts concluding in FY 1984. Using the information from previous activities, a waste characterization data base and Resource Conservation and Recovery Act impact assessment will be compiled in FY 1984.

FY 1984 BUDGET (BA in millions)

o Coal Preparation..	$ 5.0

- Define basic technological design and operating requirements for cleaning U.S. coals to quality levels comparable with oil.
- Evaluate critical engineering design and performance issues in fine coal cleaning and conditioning, chemical cleaning, and low rank coal beneficiation.

o Flue Gas Cleanup..	$ 7.6

- Complete testing of the electron beam/ammonia PDU
- Continue the development of combined NO_x/SO_x flue gas cleanup concepts.
- Initiate systems integration studies to combine $NO_x/SO_x/$ particulate capture in one process.

o Gas Stream Cleanup..	$ 4.5

- Continue lab scale R&D effort on particulate and alkali removal concepts.
- Complete preliminary economic/performance analysis for selected pressurized fluidized bed combustion cleanup devices.
- Test the zinc ferrite desulfurization process on one gasifier.

HEAT ENGINES

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$15.4	$ 5.0	$ 1.0

The Heat Engines program is directed toward establishing a firm technology base which could enable the private sector to assess technical data and ultimately, the commercial viability of coal-fired power conversion systems. Current efforts are focused on high risk research on the use of coal-liquid slurry mixtures and coal-derived gaseous fuels in such heat engines as gas turbines and diesel engines.

FY 1984 Budget ($ in millions)

o Heat Engines	$ 1.0

- The technology base efforts initiated in FY 1982-1983 period will be completed and a final report including detailed analyses of the data will be prepared and distributed to interested Federal agencies and private sector concerns.

COMBUSTION SYSTEMS

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$30.5	$24.2	$ 8.4

The objective of the Combustion Systems activity is to conduct generic technology base development with potential for high payoff related to advanced coal and coal-derived fuel combustion concepts. These research efforts are intended to establish the technology base from which industry can develop, demonstrate and commercialize improved systems which can allow for the expanded utilization of coal in an environmentally acceptable manner; particularly, as a replacement for oil and/or natural gas in utility, industrial, residential/commercial and transportation applications. The programs involve generic research on atmospheric and pressurized fluidized bed combustion and alternate fuel mixtures.

In FY 1983, work was completed in the operational phase of the atmospheric fluidized bed (AFB) industrial-scale projects at Georgetown University in Washington, D.C., at Shamokin, Penn., and at the Great Lakes Naval Training Center near Chicago. Construction was begun on two AFB boilers, in East Stroudsburg and Wilkes-Barre, Penn. Also, the initial evaluation of seven advanced atmospheric fluidized bed concepts was completed. The final Federal funding shares for the construction of the pressurized fluidized bed pilot plant at Wood-Ridge, New Jersey, and the operation of the IEA project in Grimethorpe, England, were provided. Operation continued at the New York University, Long Term Materials, and CURL PFB test facilities. Testing also continued to characterize coal-water slurry and other coal-liquids mixture technologies.

FY 1984 BUDGET ($ in Millions)

- Atmospheric Fluidized Bed Combustion .... $ 1.0
  - Conduct bench-scale testing of the most promising of the previously identified advanced AFB concepts.
- Pressurized Fluidized Bed Combustion .... $ 3.4
  - Evaluate a wide range of alternate coal feedstocks, i.e., coal-water, lignite, large (run-of-mine) coal.
  - Continue the long-term materials program.
- Alternative Fuel Utilization .... $ 4.0
  - Continue coal-water mixtures characterization efforts initiated in FY 1982.
  - Continue efforts in other coal-liquid mixtures technology areas (peat-coal-ethanol/methanol, etc.) to expand potential application into new-use areas. Specific attention to fuel particle size and distribution phenomena.

FUEL CELLS

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$34.5	$30.1	$ 9.5

The objective of the Fuel Cell activity is to establish technical feasibility of fuel cell power plants for electric utility applications, industrial cogeneration, and for on-site total energy systems. The fuel cell system is a revolutionary hydrocarbon fuel conversion technology to increase the cost effective, efficient and environmentally acceptable use of conventional and alternative hydrocarbon fuels, thereby reducing demand for oil.

The Fuel Cell program is developing technology for phosphoric acid, molten carbonate and solid oxide fuel cells. The program is part of an overall mission-oriented effort in which the private sector is responsible for demonstration and commercialization activities, the bulk of the engineering activities and part of the technology base development, with the government funding some generic technology base development of the cell and stack technology components.

Research in the area of thermionics will be completed in FY 1983.

FY 1984 BUDGET ($ in Millions)

o Advanced Concepts	$ 1.5
- Research efforts on solid oxide fuel cells will be focused on continuing selected technology base efforts, including the completion of the first integrated system design.	
o Molten Carbonate Systems Development	$ 5.0
- Fabrication and test of full area cells. - Test cells with advanced integrated components. - Complete 10,000 hour test of commercial cell type	
o Phosphoric Acid Systems Development	$ 3.0
- Continue electric utility R&D subscale stack tests.	

MAGNETOHYDRODYNAMICS

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$21.8	$29.0	$ 0

The Department began significant Magnetohydrodynamics (MHD) development programs in 1974. MHD is a long-range energy conversion technology with the potential of converting coal to electricity with high overall efficiency (in the 48-55 percent range, in mature systems, compared to about 35 percent for conventional coal fired systems), low cost of electricity, and low environmental intrusion with direct coal firing.

The FY 1983 program focused on the continued development of coal-fired MHD technology with emphasis on power train testing at the Component Development and Integration Facility (CDIF), at Butte, Montana, and the Heat Recovery Seed Recovery (HRSR) trains at the Coal Fired Flow Facility (CFFF), at Tullahoma, Tennessee. The objective has been to establish the critical technology base for subsequent industrial commercialization of MHD systems by the private sector.

The Department proposes to phase out the MHD program beginning in FY 1983 and to close out facilities and bring other ongoing efforts to an orderly conclusion. Although MHD is one of several advanced fossil energy technologies that could potentially increase power plant efficiencies and improve the environmental performance of coal-fired powerplants, it has much higher development risks and costs relative to other advanced electricity generating technologies under development. The MHD program will entail future development costs as high as $250 million for continued technology base research and up to $300 million for a multimegawatt proof-of-concept facility while offering potential benefits similar to these other coal-based options. In light of this, no funds have been requested in FY 1984 for continuing the development of MHD technology.

The Department will notify Congress prior to initiating these proposed close-out activities.

PETROLEUM

ENHANCED OIL RECOVERY

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$16.2	$ 6.5	$11.25

The goal of the Enhanced Oil Recovery (EOR) program is to conduct generic technology base R&D activities and to assist industry in obtaining a better understanding of the mechanisms and behavior of advanced and novel EOR processes for heavy oil, light oil, and tar sands.

In FY 1983, the final report was completed on the long-term test of the downhole steam generator, a concept now being developed for commercial application by several private firms. In a related area, evaluations of a concept for insulating the well string to permit deeper injection of steam for heavy oil recovery were completed. Monitoring of the on-going cost-shared and Economic Regulatory Administration incentive test projects continued, as did several university research programs attempting to improve the basic understanding of light and heavy oil recovery processes. Several field experiments of steam with foam and one involving miscible gas flooding were completed. An in-depth analysis and tabulation of candidate U.S. reservoirs for miscible gas and chemical flooding was also completed and made available for public use.

The FY 1984 budget request of $11.25 million for enhanced oil recovery represents an increase over the $6.5 million appropriated by the Congress in FY 1983. The increase would be principally applied to expanding fundamental research in flow properties, combustion kinetics, steam mobility control, steam additives and thermal mapping for heavy oil recovery, and increasing the research program in rock/fluid interactions, mobility control, chemical stability, predictive models, data base development and technology transfer for light oil recovery. A smaller increase would also be used to increase experimental work for in-situ recovery of oil from tar sands using a block test apparatus and for defining process parameters for steam flooding and in-situ combustion in tar sand reservoirs.

FY 1984 Budget ($ in millions)

o Heavy Oil	$ 3.7

- Initiate studies on the effect of noncondensable gases with steam relative to improved oil recovery.
- Perform post-flood analyses of City of Long Beach and Aminoil's caustic floods.
- Begin experiments on unconsolidated formations to verify theory and model for horizontal holes (heavy oil mining R&D).
- Analyze results of controlled source and high frequency electromagnetic tracking results for an in situ combustion and/or steam recovery project.
- Complete the mathematical model for fuel deposition and related parameters of the in situ combustion process.
- Complete studies on the effect of pressure temperature on reservoir parameters.
- Complete survey and analysis of potential techniques for determining steam quality and initiate development of test equipment of selected techniques.
- Begin combustion tube tests to determine effects of using oxygen injection as an alternative to air on the kinetics of the in situ combustion process and model the results.
- Continue international research activities.

o Light Oil	$ 6.6

- Continue chemical and miscible gas flooding R&D consisting of fundamental research on displacement mechanisms and advanced recovery processes; EOR data base analysis related to FE and ERA-incentive tests.
- Expand research on rock-fluid interactions in chemical flooding; miscible gas plus additives development; EOR data base extension and post-test analyses.

o Tar Sands	$ 1.0

- Continue R&D efforts into displacement mechanisms, forward and reverse in situ combustion methods, hot fluid injection such as cyclic steaming and steam flooding, tar sand mining, recovery through underground mining and drilling techniques, environmental research for both air and water quality, and alternate extraction technologies.
- Continue technology exchange agreements with Venezuela and Canada.

ADVANCED PROCESS TECHNOLOGY

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$4.0	$5.0	$2.9

The goal of the Advanced Process Technology (APT) program is to pursue the identification and development of advanced extraction, processing, and utilization concepts and technology related to oil, gas, tar sands, shale oil and unconventional hydrocarbons.

Within this program are efforts to assist industry in developing novel and innovative technology, such as microbial enhanced oil recovery, to increase the efficiency of extracting usable fuels from oil, gas and shale resources. New, improved analytical methodolgy and the instruments necessary to determine the chemical and physical properties and the composition of liquid fossil fuels are also expected to emerge from the generic research conducted under this budget item. Also included is the fundamental research necessary to identify, isolate, and remove toxic products from heavy crude, shale oil, and tar sand bitumen.

In FY 1983, a new initiative was undertaken in this program dealing with high-risk research related to Arctic and offshore environments. Specific activities were begun to study such areas as seafloor engineering and sea-ice dynamics.

Within this activity is also the coordination and planning of advanced petroleum- and gas-related research, including the Office of Fossil Energy's involvement in international activities.

FY 1984 Budget ($ in Millions)

- o Advanced Exploratory Research .... $ 2.2
  - Continue basic research into separation techniques development, crude oil analyses, instrumentation and technique development, and storage/handling fuel stability studies regarding petroleum products and resources.
  - Perform basic characterization research on Cerro Negro heavy crudes under a cooperative agreement with Venezuela.
- o Arctic and Offshore Research .... $ 0.7
  - Continue monitoring and coordinating role for energy-related Government Arctic research activities.
  - Standardize the collection, correlation and analysis of data to establish a uniform data base of Arctic and offshore information.

OIL SHALE

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$19.2	$12.3	$ 8.6

The Oil Shale program is designed to develop a sound technology base in oil shale chemistry and engineering which will assist industry in the development of oil shale technology.

The U.S. oil shale resource is estimated to be about two trillion barrels of oil equivalent with the richest deposits found in the states of Colorado, Utah, and Wyoming. Substantial lower quality resources also occur in the East. Oil shale technology is now in the process of moving from the laboratory and pilot plant stage to the first commercial attempts. The first plants can comply with current environmental standards using available technology; however, over a period of time, it may be necessary to mitigate environmental pollution because of regional impacts. Water quality may also prove to be a constraint on the expansion of a western oil shale industry.

In view of these potential limitations on the future contribution of oil shale to the Nation's energy mix, the Federal program was reoriented in FY 1982 and FY 1983 away from major project activities and toward the completion of data analysis and generic research from which a new generation of more efficient and environmentally acceptable oil shale processes might emerge. The FY 1984 program would continue, although at a reduced scope, basic research begun in FY 1983 on the chemistry and physics of oil shale processes and the study of the environmental implications of various oil shale conversion mechanisms.

FY 1984 Budget (BA in millions)

o Oil Shale Technology Base	$ 4.3

- Continue laboratory research on chemistry and kinetics of shale conversion.
- Continue evaluation of explosive fracture tests to provide guidance for new laboratory experiments.
- Materials transport research, completion of evaluation of fracture test series, new laboratory research in support of fracture modeling and diagnostics, tests of hypotheses for new concepts.
- Complete innovative concept studies regarding Eastern shales.

o Environmental Mitigation	$ 4.3

- Continue laboratory research on chemistry and cleanup of water and air pollutants from retorting and maintain compliance activities.
- Effects of process parameters on pollutant emissions, evaluation of data, and implementation of control technology tests at field sites.
- Develop data to assist industry to mitigate problems regarding air emission control procedures, water management systems, and solid waste management strategies. Transfer retort abandonment models completed in FY 1983 to industry.

GAS

UNCONVENTIONAL GAS RECOVERY

(Budget Authority in Millions)

FY 1982	FY 1983	FY 1984 Request
$ 8.7	$13.9	$ 5.0

Natural gas currently supplies about 25 percent of the total energy consumed in the United States. For almost ten years, the annual addition of gas reserves from new discoveries has been less than the withdrawals from existing, proven reserves, although since the late 1970's the difference between withdrawals and additions has been steadily decreasing. This change is a result of increased exploration activity resulting from partial price decontrol. This trend has shown that considerable conventional shallow and deep gas may be available for immediate use, and that gas resulting from successful research on unconventional resources, combined with this conventional gas, represents a secure domestic supply that could meet the Nation's needs into the next century.

The Unconventional Gas Recovery program has the goal of assisting the private sector in developing cost-effective diagnostic and extraction technologies required to produce gas efficiently and economically from gas resources currently unrecoverable with state-of-the-art technology. Unconventional sources of gas typically include the eastern Devonian gas shales, western gas sands, methane from coalbeds, geopressured gas, methane hydrates, and abiogenic gas.

FY 1984 Budget ($ in Millions)

o Eastern Gas Shales	$ 1.0
- Continue integration of all shale data into the Eastern Gas Shales projects data base.	
o Western Tight Gas Sands	$ 3.0
- Continue multi-well experiment and supporting research including field testing and data analysis.	
o Environmental and Advanced Research	$ 1.0
- Characterization of gas resource potential of methane hydrates and deep source (abiogenic) gas, as well as data analysis of environmental assessments.	

PROGRAM DIRECTION

(Budget Authority in Millions)

	FY 1982	FY 1983	FY 1984 Request
Headquarters Program Direction	$13.8	$ 9.0	$ 7.9
ETC Program Direction	$ —	$30.0	TBD

The Headquarters staff is responsible for the overall direction of the Fossil Energy program. Activities include planning, budgeting, policy formulation and implementation, and program management, monitoring and evaluation.

The Energy Technology Center's staffs are responsible for executing day-to-day project management functions for assigned programmatic areas. Activities include contract monitoring, performance of technical evaluations, development of project and procurement plans, dissemination of technical data, and other activities related to program and site support.

By May 1, 1983, we expect the agreements to transfer the Laramie and Grand Forks Energy Technology Centers to the University of Wyoming and the University of North Dakota, respectively, to become effective. All real and personal property will be transferred to the universities within 60 days after the effective date of the agreements. The Department has negotiated with each university a provision that they will employ the bulk of the Federal employees so as to maintain the integrity of the Federally-funded research program at each site.

The Department is preparing to evaluate proposals expected to be received by March 18, 1983, in response to a competitive solicitation for an operator for the Bartlesville Energy Technology Center. An agreement to transfer operating responsibility to a non-profit organization, under the guidelines of P.L. 97-394, is expected to be negotiated by early summer. The agreement will then be submitted to the Congress for a review of up to 30 days. The Bartlesville center would remain government-owned, and Federal financing of R&D would continue. The selected operator would be expected to share research costs on an increasing basis and would also be free to conduct research for sponsors other than the Department of Energy. The proposer must agree to provide current Federal employees at Bartlesville the right of first refusal to those positions for which they qualify and are needed by the operator.

The FY 1984 request submitted to the Congress on January 31, 1983, did not specify funding for the Energy Technology Center (ETC) indirect costs in the ETC Program Direction account as requested in the FY 1983 Appropriations Act. This amount is currently being identified within the $138 million budget request and will be provided to the Congress.

The FY 1984 budget request also proposes a personnel level of 560 fulltime permanent employees for the Fossil Energy headquarters and field organization. We recognize that this is considerably below the floor of 754 fulltime permanent employees currently mandated by the Congress. The President's FY 1984 budget, as part of the section dealing with General Provisions for Department of Energy activities, proposes the repeal of the statutory provisions requiring that a specified number of Federal employees be maintained. We believe this is necessary to ensure that sufficient flexibility is maintained within the Department to conduct an efficient and cost-effective Federal program. We ask that the Congress favorably consider the repeal of these statutory provisions.

FY 1984 Budget ($ in Millions)

- Provide funds for salaries, benefits, and travel for Fossil Energy Headquarters personnel during FY 1984 .... $ 7.9

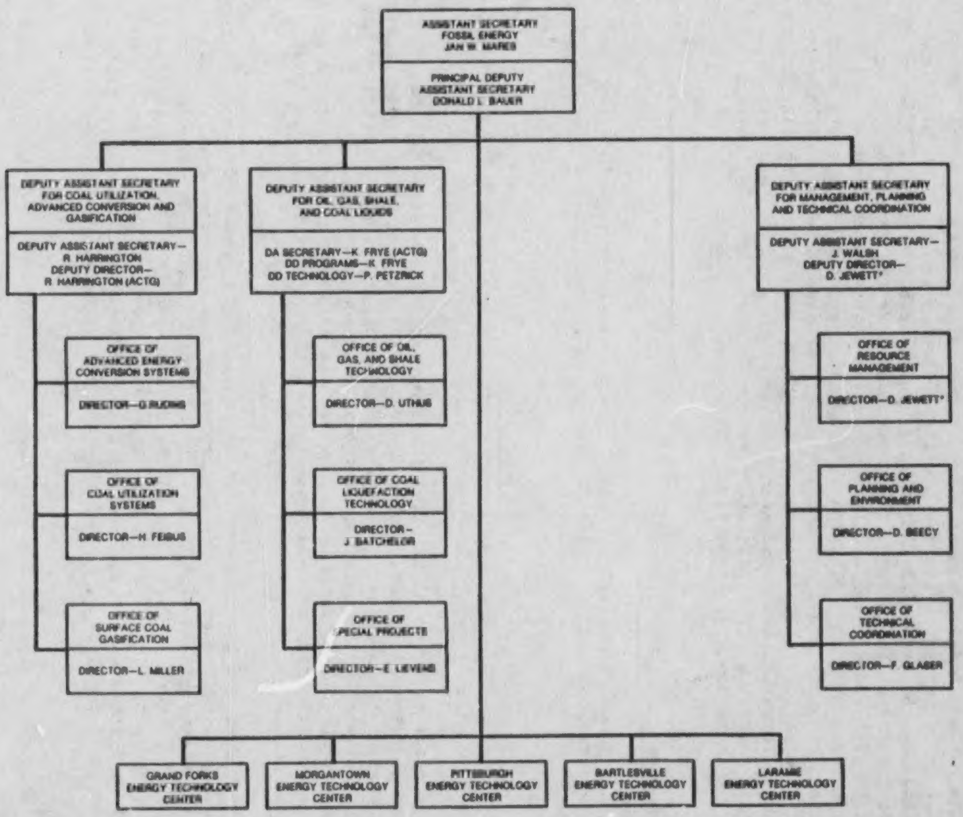
CONCLUSION

The current period of relative price moderation provides this Nation the time and opportunity to establish a sound base of technological understanding and to conduct the necessary research and development of new innovations and more cost-effective technologies that will be needed by future generations. It also provides an opportunity to develop the information needed to help mitigate environmental concerns associated with a transition to new energy systems.

The budget and the programs described will help produce the information that will be fundamental to the development of new, improved energy systems. This, we believe, is an appropriate use of public funds. By carefully focusing the Federal R&D program on the development of technologically sound data bases, rather than funding the scale-up of specific processes that may benefit only individual companies, we believe Government can play a useful role that will complement, rather than compete with, private sector initiatives.

Within the context of the budgetary constraints made necessary by the President's economic recovery program, the Fossil Energy budget proposed for FY 1984 represents a realistic approach toward fostering the technological advances needed for the future.

OFFICE OF FOSSIL ENERGY


ASSISTANT SECRETARY FOSSIL ENERGY JAN W. MARES
PRINCIPAL DEPUTY ASSISTANT SECRETARY DONALD L. BAUER
DEPUTY ASSISTANT SECRETARY FOR COAL UTILIZATION, ADVANCED CONVERSION AND GASIFICATION
DEPUTY ASSISTANT SECRETARY—R. HARRINGTON DEPUTY DIRECTOR—R. HARRINGTON (ACTG)
DEPUTY ASSISTANT SECRETARY FOR OIL, GAS, SHALE, AND COAL LIQUIDS
DA SECRETARY—K. FRYE (ACTG) DD PROGRAMS—K. FRYE DD TECHNOLOGY—P. PETZRICK
DEPUTY ASSISTANT SECRETARY FOR MANAGEMENT, PLANNING AND TECHNICAL COORDINATION
DEPUTY ASSISTANT SECRETARY—J. WALSH DEPUTY DIRECTOR—D. JEWETT*
OFFICE OF ADVANCED ENERGY CONVERSION SYSTEMS
DIRECTOR—G. RUDINS
OFFICE OF COAL UTILIZATION SYSTEMS
DIRECTOR—H. FEIBUS
OFFICE OF SURFACE COAL GASIFICATION
DIRECTOR—L. MILLER
OFFICE OF OIL, GAS, AND SHALE TECHNOLOGY
DIRECTOR—D. UTHUS
OFFICE OF COAL LIQUEFACTION TECHNOLOGY
DIRECTOR—J. BATCHELOR
OFFICE OF SPECIAL PROJECTS
DIRECTOR—E. LIEVENS
OFFICE OF RESOURCE MANAGEMENT
DIRECTOR—D. JEWETT*
OFFICE OF PLANNING AND ENVIRONMENT
DIRECTOR—D. BEECY
OFFICE OF TECHNICAL COORDINATION
DIRECTOR—F. GLASER
GRAND FORKS ENERGY TECHNOLOGY CENTER
MORGANTOWN ENERGY TECHNOLOGY CENTER
PITTSBURGH ENERGY TECHNOLOGY CENTER
BARTLESVILLE ENERGY TECHNOLOGY CENTER
LARAMIE ENERGY TECHNOLOGY CENTER

*DUAL POSITION

APPROVED OCTOBER 13, 1982

PRE-HEARING QUESTIONS AND ANSWERS

RELATING TO THE

MARCH 8, 1983 HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

COMMITTEE ON SCIENCE AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

WITNESS: JAN W. MARES

ASSISTANT SECRETARY FOR FOSSIL ENERGY

HS&T Hearing
Energy Development &
Applications Subcom.
Asked by Don Fuqua
for Hearing 3/8/83

GENERAL

Question 1: Petroleum industry executives have been recently quoted as stating that lower crude oil prices and crude oil price decontrol have significantly reduced the attractiveness of synthetic fuel development. How can you justify DOE's contention that private sector involvement will adequately displace the federal R&D efforts in programs directed at developing these fuels?

Answer: While there is no guarantee that private sector near-term research, development and demonstration will effectively displace previous Federal programs to create alternative liquids supply options such as synthetic fuels, there is evidence of significant private sector activity in this area in spite of the pessimistic near-term economic outlook for these fuels.

Firms such as Westinghouse, Exxon, and British Gas continue to develop and market advanced coal gasifiers following development work by the Federal Government. In addition, efforts are underway by several companies sponsoring advanced synfuel technologies developed outside of the Government program. For example, the Tennessee Eastman and Coolwater projects use Texaco coal gasifiers for different applications.

The Great Plains Coal Gasification and Union Oil Shale projects are well underway with the help of Federal guarantees. The Synthetic Fuels Corporation (SFC), which was created and given authority to make a variety of incentives available to encourage the private sector to build several synfuels pioneer plants, has issued three solicitations for potential synfuel projects. Letters of intent have been signed with sponsors of a peat-to-methanol, oil sands, and heavy oil project. The most recent solicitation provides strong incentives for projects in the Green River oil shale formation.

Private sector interest is evident for other alternatives to supplement conventional liquid supplies. For example, utilities and industry have assumed the initiative in preparing and burning coal-oil mixtures as a substitute for 100 percent oil firing. Also, industry has moved rapidly into the preparation and testing of coal-water mixtures in lower-risk applications.

DOE's role is currently focused on the early stages of the R&D cycle. If the financial outlook for synthetic fuels is not better when promising technology advancements from Federally-sponsored work become available, then these advancements may have to "wait on the shelf" until the market place is ready. It is the Administration's position that the private sector, responding to market forces, is best qualified to select promising technologies for further development. The Administration is, however, continuing with a sound research program which will provide a base for the future technological development of this nation.

GENERAL

Question 2: In FY 1982 and FY 1983 floors were placed on DOE headquarters and laboratory personnel levels. Is DOE's FY 1984 request consistent with those floor levels?

Answer: The FY 1982 supplemental appropriation specified miniumum employment levels for federal employees in the Fossil Energy organization. No "floors" were specified for non-federal laboratory employment. The staffing requirements included in the FY 1984 Congressional budget reflects our best management judgment on the level of federal personnel required to implement the program described in the budget and is not consistent with the specified Congressional minimum employment levels. Staffing estimates anticipate favorable action on the request to repeal the minimum employment levels and therefore are less than the legally mandated floors for Fossil Energy.

GENERAL

Question 3: Of the $138 million DOE Fossil request, how much will stay in-house at the Energy Technology Centers?

Answer: Based on the Fossil Energy FY 1984 budget request of $138 million, preliminary estimates indicate that $72,294,000 will be applied in-house at the ETC's. These estimates include direct in-house R&D costs as well as indirect costs (program direction).

BETC	$10,130,000 1/
GFETC	7,580,000 1/
LETC	8,627,000 1/
METC	22,363,000
PETC	23,594,000
Total	$72,294,000

1/ These amounts include costs for operation of the Project Offices as well as the funding requirements for the cooperative agreements to be signed in FY 1983.

GENERAL

Question 4: What colleges and universities are involved in the following programs:

a. Magnetohydrodynamics (MHD)
b. Unconventional Gas Recovery
c. Advanced Research and Technology Development
d. Fuel Cells :

Answer: The attached table shows the colleges and universities participating in the MHD, Unconventional Gas Recovery, Advanced Research and Technology Development, and Fuel Cells elements of the Fossil Energy Program during FY 1982 and FY 1983. This list may be incomplete in that the FY 1983 procurement plans have not yet been finalized.

UNIVERSITIES AND COLLEGES INVOLVED IN FOSSIL ENERGY R&D

Program	University
Magnetohydrodynamics	Mississippi State University
	Massachusetts Institute of Technology
	Stanford University
Unconventional Gas Recovery	University of Tulsa
	New Mexico Institute of Mining
	Oral Roberts University
	Kansas University
	Ohio State University
	University of Oklahoma
	Texas A&M University
Advanced Research and Technology Development	Rice University
	Yale University
	North Carolina State
	City College - New York
	New Mexico University
	University of Michigan
	University of Cincinnati
	University of Notre Dame
	Virginia Polytechnic University
	University of Pittsburgh
	Brigham Young University
	West Virginia University
	University of Pennsylvania
	Massachusetts Institute of Technology
	Washington State University
	Virginia Commonwealth University
	University of Utah
	University of Wyoming
	University of Chicago
	Colorado School of Mines
	SUNY - Buffalo
	University of Southern California
	Illinois Institute of Technology
	Auburn University
	University of Alaska
	University of Arizona
	University of California
	University of Colorado
	University of Delaware
	Southern Illinois University
	Northwestern University
	University of Illinois
	Purdue University
	Western Kentucky University
	University of Kentucky
	University of Massachusetts
	Western Michigan University

Program	University
Advanced Research and Technology Development (continued)	University of Minnesota
	Washington University
	North Carolina State University
	University of North Dakota
	New Jersey Institute of Technology
	Princeton University
	Cornell University
	University of Oklahoma
	Lehigh University
	Carnegie Mellon University
	Pennsylvania State University
	University of Rhode Island
	Brown University
	University of Tennessee
	University of Texas at Austin
	Texas A&M University
	University of Wisconsin
	Emory University
	Iowa State University
	Worchester Polytechnic Institute
	University of Missouri
	Montana State University
	SUNY - Binghamton
	Oklahoma State University
	Drexel University
	Duquesne University
	Stanford University
	Georgia Institute of Technology
Fuel Cells	Cleveland State University

GENERAL

Question 5: The management process used by DOE to transfer fossil energy funds to the national laboratories, universities, and other contractors levies a numler of indirect charges on the R&D projects to support the energy technology centers and headquarters activities; this results in less funds available for actual R&D work. Is DOE taking any actions to ensure maximum transfer of appropriated fossil energy funds to the various research projects? To what extent have the increased program direction funds alleviated this problem in FY 1983? Please provide a detailed breakout by ETC and headquarters of how those funds will be allocated?

Answer: The Fossil Energy FY 1983 Appropriation Act on December 30, 1982, provided $30 million in a Program Direction account to fund indirect costs at the Energy Technology Centers. Immediately subsequent to this, the Office of Fossil Energy undertook a detailed analysis of indirect costs at each ETC and developed standardized definitions and a method of charging such costs across all ETC's. The application of this standard methodology revealed that actual indirect costs for FY 1983 were approximately $37.9 million. In view of this, the Department recommended to the Appropriations Committee staffs that we commence charging this Program Direction account only for the last three quarters of FY 1983 resulting in approximately $30 million in indirect charges. The committee staffs agreed to this recommendation and it has since been implemented. This action will alleviate any further indirect charges against Fossil Energy R&D projects. A detailed breakout of Program Direction funding for FY 1983 by ETC is as follows:

	($ dollars in thousands)
Bartlesville Energy Technology Center	$ 3,386
Grand Forks Energy Technology Center	1,039
Laramie Energy Technology Center	1,673
Morgantown Energy Technology Center	12,075
Pittsburgh Energy Technology Center	11,380
To Be Designated/HQ Reserve	447
	$30,000

It should be noted that the Office of Fossil Energy is presently in the process of estimating the requirements for Program Direction funding in FY 1984 together with the source of funding in the FY 1984 Presidents budget and expects to transmit this information to the Congress shortly.

CONTROL TECHNOLOGY AND COAL PREPARATION

Questions 1: The FY 1984 Departmental budget submission to OMB requested $25.8 million for Control Technology . . ., but the FY 1984 Congressional budget request was reduced to $17.05 million. For each project under this line item, please provide project title, performer, objectives and funding level of work planned for at the $25.8 million request and work to be performed at the $17.05 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Control Technology and Coal Preparation (Dollars in thousands)

Coal Preparation

- FY 1984 DOE Request to OMB ($8,000)
  - Continue physical and chemical coal cleaning, dewatering and conditioning R&D at the lab/bench scale level.
  - Evaluate critical engineering design and performance issues in fine coal cleaning and conditioning, chemical cleaning, and low rank coal beneficiation.

- FY 1984 Administration's Request to Congress ($5,000)
  - Define basic technological design and operating requirements for cleaning U.S. coals to quality levels comparable with oil.
  - Evaluate critical engineering design and performance issues in fine coal cleaning and conditioning, chemical cleaning, and low rank coal beneficiation.

Flue Gas Cleanup

- FY 1984 DOE Request to OMB ($7,600)
  - Same as Administration's Request to Congress.

- FY 1984 Administration's Request to Congress ($7,600)
  - Complete testing of the electron beam/ammonia PDU.
  - Continue the development of combined NO_x/SO_x flue gas cleanup concepts.
  - Initiate systems integration studies to combine NO_x/SO_x/particulate capture in one process.

Gas Stream Cleanup

- FY 1984 DOE Request to OMB ($7,000)
  - Conduct "proof-of-concept" testing at the sub-pilot scale level for two or more PFBC cleanup systems.
  - Test most promising alkali vapor removal concepts on actual coal-fired gas stream.
  - Complete testing of selected particulate concepts at lab scale on simulated combustor gas streams.
  - Continue hot gas desulfurization (zinc ferrite system, etc.) process R&D on several gasifiers.
  - Determine combustor/gasification reactor modifications worthy of pursuit.
  - Develop adequate H_2S detection instrument.
  - Complete comprehensive economic/performance analysis for selected PFBC cleanup devices.

- FY 1984 Administration's Request to Congress ($4,450)
  - Complete testing of selected particulate concepts at lab scale.
  - Test zinc ferrite desulfurization system at a reduced level on only one gasifier.
  - Complete preliminary economic/performance analysis for selected PFBC cleanup devices.

Cleanup Base Technology

- FY 1984 DOE Request to OMB ($3,200)
  - Continue sampling and characterization of coal preparation wastes.
  - Continue research on waste disposal and utilization.
  - Conduct technical and economic assessments to determine potential of the waste utilization processes being developed.

- FY 1984 Administration's Request to Congress ($0)

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 2: What are the two chemical concepts being evaluated for cleaning coals to a level comparable to fuel oil? Who is performing the work? What funding is provided in FY 1983, in the FY 1984 request?

Answer: The two chemical processes under investigation are the TRW fused salt and the General Electric (GE) microwave process. They both have shown the ability in laboratory tests to remove 90 percent of the total sulfur and greater than 95 percent of the ash for the majority of those coals tested.

TRW Fused Salt - FY 1983 funding is $1,100,000 with emphasis on the initial phase of reagent regeneration and ash removal subsystem research. FY 1984 funding is planned to be approximately $1,000,000.

GE Microwave - FY 1983 funding is $512,000 which emphasizes the investigation of system parameter limits for enhanced performance, particularly for those reactions that take place during microwave irradiation. FY 1984 funding is planned to be approximately $500,000.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 3: What management process will be used to select the preferred chemical cleaning process to reduce sulfur and ash to comparable fuel oil levels?

Answer: A chemical coal cleaning process or system capable of reducing ash and sulfur to the levels required for the substitution of a coal based fuel (slurry or solid) for oil will be comprised of several subsystems. In fact, it is likely that an advanced physical cleaning process capable of removing significant ash and sulfur at a low cost and a high Btu recovery rate will be a front-end subsystem to the chemical cleaning part of the process. In addition to the physical cleaning and grinding subsystems, the parts of the process during which the alkali and sulfur react, the ash is dissolved, and the reagent is regenerated, are each critical subsystems. During FY 1984, the chemical coal cleaning research activities will concentrate on the chemical subsystems at both the laboratory and bench scale. The management technique utilized to select the particular approach to be developed for each subsystem and how these will be integrated into a total system relies heavily on continuing technical and economic assessments conducted by independent organizations and DOE personnel as well as those conducted by the contractors responsible for the research. The most recent of these analyses is nearing completion and the results will be used to guide the research efforts in FY 1984. Preliminary results indicate that reagent regeneration is very important in both processes. During FY 1984, the work on the microwave process will concentrate on the basic reactions associated with the microwave chamber. The fused salt activity will include work on all of the subsystems but will concentrate on reagent regeneration.

Question 4: How much of the $5 million requested for coal preparation will remain at the ETC's? (Identify organizations.)

Answer: The lead center for Coal Preparation project management and in-house research efforts is the Pittsburgh Energy Technology Center (PETC). Of the $5 million requested for FY 1984, approximately $1.8 million will remain at PETC and about $0.3 million at Grand Forks Energy Technology Center.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 5: Projects proposed in the FY 1984 coal preparation subactivity would entail small scale test rigs designed to develop essential engineering data. What and where are these projects? Who will conduct them? What is the funding level?

Answer: The estimates provided for FY 1984 are preliminary and are subject to further revision. Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers. Since the performers have not yet been determined, the location is unknown. The following list sets forth those projects which entail small scale test rigs in the range of a few pounds of coal in a batch process mode:

Coal Preparation

- True-heavy-liquid beneficiation, $200,000
- High-gradient magnetic separation, $100,000
- Pilot plant continuous HGMS testing, $100,000
- Ultra-fine coal flotation, $125,000
- Microwave desulfurization, $500,000
- Fused salt process development, $1,000,000
- Low rank coal dewatering, $200,000
- Fine size coal dewatering, $90,000
- Fine size coal agglomeration, $90,000
- Ultrasonic comminution, $150,000
- On-line analysis, $100,000

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 6: Please provide a detailed description (i.e., type of work, performer, funding level) of the projects under flue gas cleanup and gas stream cleanup.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers. The type of work and funding levels for projects under the flue gas cleanup and gas stream cleanup subactivities are listed below:

Type of Work	FY 1984 Funding ($000)
Flue Gas Cleanup ($7.6 million)	
o Project management and support	$ 850
o E-Beam process evaluation for lime-spray dryer and ammonia injection	2,400
o Particulates/hydrocarbon measurement and characterization from pulverized coal and fluidized bed combustors to determine potential impacts on future control technology requirements	460
o Investigate process options for the simultaneous cleanup of flue gas NO_x/SO_x emissions from western coals	430
o Conduct research on NO_x/SO_x reaction chemistry	650
o Conduct research on electron beam precharging and acoustic agglomeration to improve capture of respirable particles	300
o Thermodynamics/thermochemical properties for compounds of interest to combined NO_x/SO_x processes	150
o Systems integration studies and process cost analysis	500
o Development of advanced NO_x/SO_x processes, e.g., fluidized bed copper oxide, moving bed copper oxide, glow discharge process, SULF-X process, zinc oxide spray dryer, zeolite supported metal sorbent process	1,860
Gas Stream Cleanup ($4.45 million)	
o Gas Turbine Cleanup	$3,000
- Ceramic cross flow filter	
- Tubular electrostatic precipitator	
- Alkali formation research	
- Electrostatic precipitator research	
- Dry plate scrubber	
- Granular bed filter	
- Cyclone research	
- Acoustic agglomeration research	
- Ceramic bag research	
- Preliminary economic-technical feasibility studies	

Type of Work	FY 1984 Funding ($000)
o Process Modification	$ 450
- Evaluation of process modification techniques	
- Sulfate formation	
- R&D on characterization of in-process contaminants	
- Study of contaminant formation	
o Fuel Cell Cleanup	$1,000
- H_2S sorbent research	
- Trace sulfur and arsenic cleanup	
- Halogen removal from HTHP gas streams	
- Study of particulate effect on MCFC	
- Trace SO_2 removal from MCFC	

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 7: Where is the research on the characterization of hydrocarbon emissions and particulates being performed?

Answer: Research on hydrocarbon emissions is being performed at the Grand Forks Energy Technology Center (GFETC). Pollutant characterization of gas streams has also been conducted by Westinghouse using their fluidized bed gasifier at Waltz Mills, Pa. In addition, West Virginia University studied the control and formation of hydrocarbon emissions from gasifier processes. For FY 1984, various gas streams will be instrumented during R&D tests for contaminant control devices. The control devices planned for tests include the zinc ferrite H_2S sorbent system on a fixed bed gasifier, particulate removal devices on selected combustor gas streams and possibly an alkali control system on a selected combustor facility.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 8: Where will the R&D work for removal of particulate and alkali contaminants from the combustion gas stream be performed?

Answer: All of the contractors for the particulate and alkali removal research in FY 1984 have not been identified. There are a number of candidate projects in the particulate and alkali research area presently underway in FY 1983. If these FY 1983 projects continue to be promising, they will be considered for funding in FY 1984. Also, several research areas are contemplated and will be selected competitively. Potential contractors for research in alkali and particulate removal could include but are not limited to:

- Westinghouse - Cross Flow Filters - Testing at Argonne National Labs, Chicago, Ill.
- Air Pollution Technology - Dry Plate Scrubber - San Diego, Calif.
- Combustion Power Corporation - Moving Granular Bed Filter, Mendo Park, Calif.
- Argonne National Labs - Alklai Sorbent Research - Chicago, Ill.
- Aerodyne Research - Alkali Formation Research - Boston, Mass.
- METC - Gasification Particle Control Work - Morgantown, W. Va.
- General Electric - Granular Bed Filter - Malta, N.Y.
- Research Cottrell and Denver Research - Electrostatic Precipitators - Denver, Colo.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 9: Who will be conducting tests on the zinc ferrite desulfurization process?

Answer: The zinc ferrite desulfurization process was developed by METC. This promising H_2S sorbtion process is scheduled for on-line gas stream testing with their fixed bed gasifier the third quarter of FY 1983 with testing to continue through FY 1984.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 10: What projects will be terminated in the gas stream cleanup subactivity?

Answer: Considering the FY 1984 budget the following activities will be terminated or reduced in scope:

- Five lab scale particulate removal concepts have been under development. This number will be reduced in FY 1984 and the remaining concepts will be tested at the lab scale on an actual coal-fired combustor.
- The scope of activities for the METC zinc ferrite desulfurization process will be reduced. Testing of the zinc ferrite desulfurization process will be conducted on one gasifier instead of three. Testing on the fluid bed and entrained bed gasifiers will be eliminated.
- An actual coal-fired gas stream test of a selected alkali sorption system will be eliminated with the substitution of a synthetic gas stream.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 11: Please list the previous industrial participants in the cleanup base technology subactivity.

Answer: The following list summarizes the industrial participants in the cleanup base technology subactivity:

Contractor	Project Title
Aerodyne, Inc.	NO_x reduction reactions
EG&G	Applied research technology support
Exxon	Formation of NO_x
Science Applications, Inc.	Project management support
Extranuclear	Particulates monitoring
PEDCO	Acid rain study
Spectron	In-situ particle determination
Ecoenergetics	Biological dewatering
Minnick	Constructive use of FBC waste
EG&G	Model data base

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 12: Who will compile the waste characterization data base and RCRA impact assessment?

Answer: The initial waste sampling and characterization effort was performed with the cooperation of 18 utilities from various regions of the country and focused on 5 emerging technologies. A number of commercial laboratories as well as several National Labs and Energy Technology Centers participated in the analysis. The Laramie Energy Technology Center (LETC) has the assigned project responsibility. The waste characterization data base is being compiled at LETC with a multilab characterization report due by August 31, 1983, and a sampling and characterization executive summary report due by September 30, 1983. A data base for waste from oil shale processing has been prepared by LETC.

The RCRA impact assessment project has been conducted by Engineering Science, Atlanta, GA., under a multi-year funding basis. A number of topical reports have been published. The final report, which will include the utility and industrial sectors as well as several emerging technologies, will be available by September 30, 1983.

CONTROL TECHNOLOGY AND COAL PREPARATION

Question 13: What flue gas activities are being funded by EPA and how does that activity compare with DOE planned activities?

Answer: The parallel EPA control technology program can generally be categorized into the following areas:

- Flue Gas Desulfurization
- Particulate Control
- Combustion Modification
- Limestone Injected Multi-Stage Burner (LIMB) Process

The flue gas desulfurization effort basically concentrates on evolutionary improvements to more or less existing processes in order to reduce costs and increase performance and reliability. Included in this area is research on additives for limestone scrubbing processes, characterization of spray dryer performance/costs, spray dryer and dual alkali process research to effect a substitution of limestone for the more expensive lime, and support of the Niagara-Mohawk aqueous carbonate desulfurization process demonstration.

The goal of the particulate control work is primarily cost reduction along with improving collection efficiency for high resistivity, low sulfur western coals. The techniques under development are precharging for electrostatic precipitator (ESP) applications and electrostatic enhancement of fabric filtration.

Although the combustion modification work is not flue gas cleanup per se, it represents an alternate approach to NO_x emissions control. The staged combustion/low NO_x burner techniques offer the potential of 60 to 70 percent reduction in NO_x emissions.

The LIMB concept is a mating of the low NO_x burner approach with limestone injection into the combustor for SO_x control. The objective of this effort is near term development of a low cost system for retrofit to coal-fired boilers for acid rain abatement.

By contrast, the DOE flue gas program is concentrating on more basic and generic process research and development of novel concepts for the simultaneous control of both NO_x and SO_x at the 90 percent level at costs less than those for separate control processes. Furthermore, the processes are selected for consideration based on waste/byproduct characteristics to avoid sludge handling and disposal problems and costs. Research on particulate and hydrocarbon emissions is supported to assist in the assessment of the impact of potential future environmental regulations on control technology requirements. Specific particulate control research is underway to enhance collection efficiency of respirable particles. The techniques under study are electron beam precharging and acoustic agglomeration.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 1: The FY 1984 Departmental budget submission to OMB requested $50.36 million for AR&TD, but the FY 1984 Congressional budget request was reduced to $30.54 million. Please provide project title, performer, objectives, and funding level of work planned for at the $50.36 million request and the $30.54 million request?

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Advanced Research and Technology Development (Dollars in thousands)

Direct Utilization

- FY 1984 DOE Request to OMB ($9,000)
  - Continue coal combustion research.
  - Begin preliminary bench scale assessment of selected advanced combustor concepts.
  - Continue generic research in coal cleaning and control technology.
- FY 1984 Administration's Request to Congress ($4,800)
  - Continue coal combustion research at a reduced level of effort.
  - Continue research related to improving combustion processes for fluidized-bed technology.

Materials and Components

- FY 1984 Request to OMB ($9,000)
  - Continue research in the areas of high temperature corrosion, slag refractory interactions, structural ceramics, hydrogen effects, and erosion wear.
  - Continue studies and research on advanced component concepts (heat exchangers, pumps, valves, etc).
- FY 1984 Administration's Request to Congress ($6,500)
  - Continue aspects of the research program related to high temperature corrosion, slag refractory interactions, structural ceramics, hydrogen effects, and erosion wear.
  - Continue studies and research on advanced component concepts (heat exchangers, pumps, valves, etc).

Processes

- o FY 1984 DOE Request to OMB ($10,000)
  - Continue research, principally at ETC's, on low rank coal liquefaction, development of analytical techniques and reaction chemistry.
  - Conduct research on advanced liquefaction concepts.
  - Continue research on catalysis and kinetics, structure and reactivity of coal, properties of coal, properties of coal liquids, and liquefaction of synthesis gas.
  - Continue some research on coal conversion processes to advance gasification to the next generation of development.
  - Continue research along a broad technical front involving kinetics, thermodynamics, catalytic mechanisms, modeling, hydrogasification, pyrolysis, fluidization studies, acid gas removal, hot gas cleanup, gas separation, conversion studies and novel concepts of gas generation by reaction of coal with steam, air and oxygen. Continue basic studies on coal gasification during gasification.

- o FY 1984 Administration's Request to Congress ($7,000)
  - Continue research, principally at ETC's at a lower level of effort, on low rank coal liquefaction, development of analytical techniques and reaction chemistry.
  - Conduct research on aspects of advanced liquefaction concepts.
  - Continue limited research on catalysis and kinetics, structure and reactivity of coal, properties of coal, properties of coal liquids, and liquefaction of synthesis gas.
  - Continue research, at a reduced level of effort, on coal conversion fundamentals to generate data needed to advance the state-of-the-art of gasification to the next generation of development.
  - Continue limited research involving kinetics, thermodynamics, catalytic mechanisms, modeling, hydrogasification, pyrolysis, fluidization studies, acid gas removal, hot gas cleanup, gas separation, conversion studies and novel concepts of gas generation by reaction of coal with steam, air and oxygen.

Program Development and Coordination

- o FY 1984 DOE Request to OMB ($12,860)
  - Perform crosscutting support for policy development, R&D assessment and compliance overview for Fossil Energy.
  - Continue centralized planning and policy development for Fossil Energy.
  - Pursue technology base assessment and coordination activities.
  - Pursue generic research in the areas of improved sensors, techniques and applications.
  - Provide funding for GPP and wastewater treatment facilities.

- o FY 1984 Administration's Request to Congress ($6,740)
  - Perform crosscutting support for policy development, R&D assessment and ES&H compliance overview for Fossil Energy.
  - Continue overall planning and policy development for Fossil Energy.
  - Provide funding for GPP and waste water treatment facilities.

University Coal Research

- FY 1984 DOE Request to OMB ($5,500)
  - Initiate or review approximately 40 university projects directed at improving the fundamental scientific and technical understanding of the chemical and physical processes involved in the conversion and utilization of coal.

- FY 1984 Administration's Request to Congress ($4,000)
  - Initiate or renew approximately 25 university projects directed at improving the fundamental scientific and technical understanding of the chemical and physical processes involved in the conversion and utilization of coal.

Capital Equipment

- FY 1984 DOE Request to OMB ($3,000)
  - Provides for necessary capital equipment at ETC's and National Labs under expansion of program.

- FY 1984 Administration's Request to Congress ($1,500)
  - Provides for necessary capital equipment at ETC's and National Labs.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 2: Please provide information on the type of project, the performer, objectives, and funding level for: processes (liquefaction and gasification), direct utilization, materials, components, and university research.

Answer: The information requested has been provided in response to Question 1 of the Advanced Research and Technology Development section.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 3: How much funding does each ETC receive in the liquefaction and gasification subactivities? What portion of that funding remains in-house and how much is contracted out?

Answer: The FY 1984 Coal Liquefaction and Surface Coal Gasification allocations for the Energy Technology Centers are reflected below. This data is based on very preliminary estimates for FY 1984 and represents the best estimates of the ETC's and Fossil Energy Headquarters at this stage of the budget process.

($ in thousands)

FY 1984 Coal Liquefaction Processes Activities

	In-house	Contracts	Total
BETC	149	81	230
GFETC	43	207	250
PETC	1851	1069	2920

FY 1984 Surface Coal Gasification Processes Activities

	In-house	Contracts	Total
GFETC	33	267	300
METC	1328	1522	2850

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 4: How much funding will the Combustion Research Facility receive from the direct utilization activity in FY 1984? How much in FY 1983?

Answer: The preliminary estimates of the direct utilization funding allocations for Sandia's Combustion Research Facility are shown below:

FY 1983	FY 1984
$550,000	$417,000

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 5: Please prepare a summary comparison of FY 1983 and FY 1984 programs in the direct utilization and materials and components subactivities.

Answer:

Direct Utilization

- FY 1983 Appropriation ($10.6 million)
  - Enhance data base and phenomenological understanding of fundamental chemical and physical processes critical to the design and performance of improved coal combustion systems.
  - Expand diagnostic and modeling capability to support design of improved coal combustion systems.
  - Conduct preliminary assessment of selected advanced concepts for improved combustion systems.
  - Fundamental research on electrochemical reactions of coal.
  - Explore new material catalysts, and electrolytes for fuel cell systems.
  - Continue studies of coal-ash behavior and fluidized bed systems and investigate improved downstream processing techniques.
  - Continue work on peat dewatering, harvesting and wet carbonization.
- FY 1984 Administration's Request to Congress ($4.8 million)
  - Enhance data base on the combustion characteristics of beneficiated coals.
  - Continue coal combustion research at a reduced level of effort.
  - Continue aspects of the generic research program related to coal cleaning and control technology.
  - Continue research related to improving combustion processes for fluidized-bed technology.

Materials and Components

- FY 1983 Appropriation ($7.8 million)
  - Increase materials research in such areas as structural ceramics, fluid corrosion mechanisms, high temperature corrosion, and slag refractory interaction.
  - Continue studies on the effects of environment on structural materials.
  - Develop an understanding of basic concepts for components and process conversion problems.
- FY 1984 Administration's Request to Congress ($6.5 million)
  - Continue aspects of the research program related to high temperature corrosion, slag refractory interactions, structural ceramics, hyrdogen effects, and erosion wear.
  - Continue, at a reduced level of effort, research into novel heat exchanger concepts.
  - Continue research on novel, advanced dirty gas valve concepts such as power fluidics, and multiple orifices.
  - Continue limited efforts on slurry pumps and subsystems such as check valves, seals, and materials for stuffing boxes.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 6: How much of the $2 million for GPP will each ETC receive?

Answer: In FY 1984, the Morgantown Energy Technology Center and the Pittsburgh Energy Technology Center will each receive $1 million for General Plant Projects (GPP).

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 7: Please provide a table which indicates, by national laboratory, the funds available for each subactivity in FY 1983 and FY 1984.

Answer:

	(dollars in thousands) B/A FY 1983	B/A FY 1984
Argonne National Laboratory		
Direct Utilization	80	0
Materials & Components	855	760
Processes	100	100
Program Development & Coordination	445	262
Capital Equipment	100	100
	1,580	1,222
Brookhaven National Laboratory		
Processes	500	379
Capital Equipment	0	0
	500	379
Idaho National Engineering Laboratory		
Materials & Components	160	122
Capital Equipment	0	0
	160	122
Lawrence Berkeley Laboratory		
Materials & Components	416	250
Processes	209	224
Capital Equipment	0	0
	625	474
Los Alamos National Laboratory		
Materials & Components	250	310
Processes	160	0
Capital Equipment	100	100
	510	410
Lawrence Livermore Laboratory		
Capital Equipment	50	50
Oak Ridge National Laboratory		
Materials & Components	4,654	3,925
Processes	350	100
Program Development & Coordination	466	121
Capital Equipment	100	100
	5,570	4,246
Pacific Northwest Lab		
Materials & Components	225	360
Processes	250	0
Capital Equipment	0	0
	475	360
Sandia Laboratory		
Direct Utilization	550	417
Capital Equipment	150	150
	700	567

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 8: What environmental activities will be terminated in FY 1984 since a $1 million reduction is requested? Please provide justification for any terminations.

Answer: The Department does not plan to terminate any of the environmental activities associated with the Fossil Energy R&D program in FY 1984. Major functions of the program, such as the overview of programs and projects to ensure that they comply with NEPA, the Clean Air Act, the Occupational Safety and Health Act, and other relevant statutes, will be continued but at a reduced scope.

In that Fossil Energy is planning on limiting its activites principally to bench scale and laboratory scale R&D, the depth and scope of environmental review will accordingly be reduced especially when compared to the level and intensity required in past years when major projects (e.g., EDS, H-Coal, SRC-I, SRC-II) were underway.

ADVANCED RESEARCH AND TECHNOLOGY DEVELOPMENT

Question 9: The FY 1983 appropriation language specified $2 million for work on fuel cell systems. What research will be conducted? Who will do the work and where? What deliverables are planned?

Answer: The work being carried out at National Laboratories and at NASA. The following describes these efforts.

Research Study	Performer	Budget	Deliverable
Phosporic acid electrode interface studies and applications analysis	Los Alamos Nat'l Lab	$200,000	Report
High temperature fuel cell materials	Brookhaven Nat'l Lab	$200,000	Report
Catalytic research for acid fuel cells	Lawrence Berkeley Nat'l Lab	$150,000	Report
Solid oxide & molten carbonate electrode & electrolyte research	Argonne Nat'l Lab	$600,000	Report
Fuel reforming research, phosporic acid system analysis and materials research	NASA	$700,000	Report
Coal gasifier-fuel cell integration and catalysts	To be determined	$150,000	Report

COAL LIQUEFACTION

Question 1: The FY 1984 Department budget submission to OMB requested $41.84 million for coal liquefaction, but the FY 1984 Congressional budget request was substantially (-59%) reduced from that request. Please provide project title, performer, objectives, and funding level of work planned for at the $41.84 million request and the $17 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Coal Liquefaction (Dollars in thousands)

Indirect Liquefaction

- FY 1984 DOE Request to OMB ($12,400)
  - Complete DOE funding of MTG project with the Federal Republic of Germany to obtain data from fluid bed design to permit industry to scale up the process concept.
  - Provide proof of concept for liquid phase methanol technology and conduct bench scale research on three phase reactors and advanced catalyst concepts to obtain data on three phase reactor systems with slurry catalysts, required in order to best utilize synthesis gas from U.S. coals and new gasifiers in production of clean liquid fuels.

- FY 1984 Administration's Request to Congress ($4,000)
  - Complete DOE funding of MTG project with the Federal Republic of Germany.
  - Conduct reduced level of bench scale research with three phase reactors and advanced catalysts.

Advanced Process Development

- FY 1984 DOE Request to OMB ($22,000)
  - Continue bench scale R&D in catalyst development and improved process concepts.
  - Continue slurry phase catalyst development and process research.
  - Continue bench scale development of integrated two-stage liquefaction.
  - Continue proof of concept evaluation of advanced process concepts at Wilsonville facility.

- FY 1984 Administration's Request to Congress ($9,000)
  - Continue selected bench scale R&D in catalyst development and improved process concepts.
  - Continue bench scale development of integrated two-stage liquefaction until June 1984.

Support Studies/Engineering Evaluations

- FY 1984 DOE Request to OMB ($7,000)
  - Continue engineering evaluations and component research.
  - Continue health effects and data base management activities.
- FY 1984 Administration's Request to Congress ($4,000)
  - Continue engineering evaluations and component research at a reduced level of effort.
  - Continue limited health effects and data base management activities.

COAL LIQUEFACTION

Question 2: How much of the $4 million requested for indirect liquefaction is for the MTG/FRG project? Other activity?

Answer: We estimate about $500,000 will be adequate to complete funding of the MTG/FRG project in FY 1984. However, this amount could change slightly due to fluctuations in the international monetary exchange rate. The remaining funds will support PETC in-house research and continue one contract that is investigating the kinetics and hydrodynamics of a three-phase reactor with advanced catalyst systems.

Question 3: Since the request does not include funding for the liquid phase methanol project with Air Products, what are the plans for the PDU at LaPorte, Texas?

Answer: We are discussing, with our cost sharing industrial participants, the possibility of operating the PDU without government support, and we are willing to turn the facility over to them for operation. If this proves to be impractical, we may have to curtail the activities during the next few months and proceed with an orderly termination of the project.

COAL LIQUEFACTION

Question 4: Please justify the phase out of work on inexpensive synthetic catalysts.

Answer: Naturally occuring mineral matter in coal, primarily iron compounds, promote coal hydrogenation reactions. It has been well established in the catalyst technology that some other transition metals (e.g., Co, MO, Wn) are many times more active than iron in promoting hydrogenation reactions with hydrocarbons. Synthetic slurry catalysts incorporating these metals may be effective at very low concentrations in promoting selective coal liquefaction reactions. The Fossil Energy program, due to the overall stance of the Federal budget, must make some difficult choices among competing technologies and establish priorities within program areas. While the development of inexpensive synthetic slurry catalysts continues to be an attractive area for exploratory development, the work is in its infancy and the potential for successful development is not as well defined as other process concepts under development within the coal liquefaction program. As a result, Fossil Energy has opted to phase out activities in this particular area.

Question 5: How will the ETC's, National Labs, and industry be impacted by the termination of integrated bench scale testing of slurry phase catalysts?

Answer: Integrated bench scale testing of slurry phase catalysts is being conducted at the Gulf Research & Development Company, Merriam Coal Liquefaction Laboratory at Merriam, Kansas. Basic research support for this work is being conducted by Sandia National Lab and PETC. These activities would be curtailed or redirected as a result of the termination of the integrated bench scale testing of slurry phase catalysts.

COAL LIQUEFACTION

Question 6: Please list the project, performer, objectives, and funding level for FY 1983 activities under Advanced Process Development and similar information for FY 1984.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1983 Appropriation and the FY 1984 Administration's request to Congress follow:

- FY 1983 Appropriation ($18.0 million)
  - Continue activities directed towards determining the interaction of mineral matter components in coal liquefaction processes.
  - Continue research to develop catalysts and improved catalytic process concepts which reduce hydrogen consumption and increase liquid yields.
  - Complete proof-of-concept testing of integrated two stage liquefaction process with a bituminous coal at Wilsonville.
  - Complete test of a sub-bituminous coal in integrated bench scale two stage liquefaction unit.

- FY 1984 Administration's Request to Congress ($9.0 million)
  - Continue evaluation of direct catalyst liquefaction process concepts.
  - Continue studies to develop bead catalysts.
  - Continue bench scale research in the Integrated Two Stage Liquefaction (ITSL) process until mid 1984.

Question 7: Has EPRI finalized plans for operating the Wilsonville facility in FY 1984? If so, what are they? How do the reductions in process research/technology development subactivity affect Wilsonville?

Answer: EPRI, to our knowledge, has not finalized plans for operating Wilsonville beyond the current DOE/EPRI cofunded operating period ending in January 1984. Individuals responsible for the operation of EPRI's program have indicated a desire to continue cofunded operations with DOE beyond this date, and they have been seeking industrial support to augment their cofunding contribution. The DOE FY 1984 budget request does not include funds for Federal support of operation of the Wilsonville facility.

COAL LIQUEFACTION

Question 8: Please provide a description of current activities in the biomedical testing program. Who is managing/coordinating this effort? Who are the performers? What are the dollar amounts associated with each activity for FY 1983 and FY 1984?

Answer: Coal Liquefaction products contain chemicals known to produce adverse health and environmental effects. Fossil Energy (FE) supports toxicity screening programs to identify how changes in engineering parameters affect production of bioactive compounds. Among the technology options being studied in the FE coal liquids health effects program are: (1) process parameters including recycling, catalyst effects, (2) advanced technologies such as two-stage liquefaction, and (3) product upgrading encompassing hydrotreatment and refinery operations.

FE Headquarters is managing the technology related health effects screening program. The program is fully coordinated with ER, Office of Health and Environmental Research (OHER). The research is being performed at the Battelle Pacific Northwest National Laboratory (PNL) and the Oak Ridge National Laboratory (ORNL). PNL is studying changes in the health effects of coal liquids related to process modifications and advanced process developments; ORNL is studying effects from product upgrading and potential refinery operations. Funding for the total program in FY 1983 is $1.2 million and the requested funding in FY 1984 is $1.0 million.

COMBUSTION SYSTEMS

Question 1: The FY 1984 Department budget submission to OMB requested $16.7 million for Combustion Systems, but the FY 1984 Congressional budget request was reduced to $8.4 million. For each project under this line item, please provide project title, performer, objectives, and funding level at the $16.7 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Combustion Systems (Dollars in thousands)

Atmospheric Fluidized Bed Combustion

- FY 1984 DOE Request to OMB ($1,400)
  - Conduct bench-scale testing of advanced AFB concepts.
- FY 1984 Administration's Request to Congress ($1,000)
  - Same as DOE Request to OMB but at a reduced level of effort.

Pressurized Fluidized Bed Combustion

- FY 1984 DOE Request to OMB ($6,000)
  - Continue the PFB advanced concept work.
  - Evaluate alternate coal feedstocks, i.e., coal-water, lignite, large coal.
  - Continue the long-term materials program.
- FY 1984 Administration's Request to Congress ($3,400)
  - Evaluate a wide range of alternate coal feedstocks, i.e., coal-water, lignite, large (run-of-mine) coal.
  - Continue the long-term materials program.

Alternative Fuel Utilization

- FY 1984 DOE Request to OMB ($7,600)
  - Continue coal-water mixtures characterization efforts initiated in FY 1982.
  - Continue efforts in other coal-liquid mixtures technology areas (peat-coal-ethanol/methanol, etc.) to expand potential application into new-use areas.

- FY 1984 Administration's Request to Congress ($4,000)
  - Continue coal-water mixtures characterization efforts initiated in FY 1982.
  - Continue efforts in other coal-liquid mixtures technology areas (peat-coal-ethanol/methanol, etc.) to expand potential application into new-use areas.

Advanced Combustion Technology

- FY 1984 DOE Request to OMB ($1,700)
  - Initiate proof-of-concept activities for the most promising combustor candidate(s) selected from prior year research.

- FY 1984 Administration's Request to Congress ($0)

COMBUSTION SYSTEMS

Question 2: Has Curtiss-Wright secured approval for pilot plant operation for a small gas turbine operated on the PFB combustion products?

Answer: Curtiss-Wright secured all the necessary municipal building permits, as well as all applicable State and Federal environmental permits. These were all obtained prior to initiation of construction of the pilot plant in mid-year 1980.

Question 3: Is there anticipated funding in FY 1984 for the long term materials program involving GE, GRI, and New York University, and if so how much for each?

Answer: The General Electric long term materials test project is scheduled to continue through 1986. Aproximately $1.0 million is planned to fund this effort in FY 1984. The Electric Power Research Institute (EPRI) is participating in this program, not GRI.

The present contract with New York University (NYU) will expire in FY 1983. The NYU effort is directed towards pressurized fluidized bed combustion phenomena investigations and combustion characterization of low ranked fossil fuels such as lignite. Discussions are in progress with the University to determine the direction and scope for continuing efforts in FY 1984. Therefore, the funding allocation for NYU has not been finalized.

COMBUSTION SYSTEMS

Question 4: Reduced funding in this and other fossil R&D categories seems to suggest a retreat from the previously stated goal of promoting the substitution of coal for processes now using gas or oil. Is this true?

Answer: The combustion systems request of $8.4 million is consistent with a structured program of basic and generic research to provide the private sector with a sufficient data base for them to carry the technology to commercialization. Privately-funded R&D is directed at shorter-term and relatively assured positive results. The Government program, on the other hand, embraces the early exploration of longer-term concepts too risky for the private sector. Our role is to carry this early R&D to the point where private industry can assess the desirability of continuing development and deployment.

In the AFB program area, reductions in funding indicate Fossil Energy's efforts to bring the demonstration units to a logical conclusion in FY 1983 while concentrating on the advanced AFB concepts. Funds are available to bench test at least two of these concepts.

In the PFB program, funding has been reduced because the Curtiss-Wright project has been fully funded through construction and funds are being sought from the private sector for operation. Fossil Energy's involvement in the IEA-Grimethorpe will be completed in June 1984. This project was fully funded in FY 1983. Combustion Systems will be concentrating on completing the technology data base and investigating advanced PFB concepts.

Alternate Fuel Mixtures is continuing at the same level of effort in developing a data base on component and combustion characterization for industrial and utility applications.

The advanced combustion program is anticipating awarding eight contracts in the last quarter of FY 1983. No FY 1984 funds are required as prior year funds are available for Phase I of these contracts, which will last through the last quarter of FY 1984. A decision to continue funding three additional phases of this activity will also occur in the last quarter of FY 1984. Funding of these additional phases would require FY 1985 funding.

FUEL CELLS

Question 1: The FY 1984 Department budget submission to OMB requested $20.5 million for Fuel Cells, but the FY 1984 Congressional budget request was reduced to $9.5 million. For each project under this line item, please provide project title, performer, objectives, and funding level at the $20.5 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Fuel Cells (Dollars in thousands)

Advanced Concepts

- FY 1984 DOE Request to OMB ($2,000)
  - Complete solid oxide system design.
  - Initiate construction of a solid oxide 5 to 10kW sub-module.
- FY 1984 Administration's Request to Congress ($1,500)
  - Research efforts on solid oxide fuel cells will be focused on continuing selected technology base efforts.

Molten Carbonate Systems Development

- FY 1984 DOE Request to OMB $10,500)
  - Fabricate and test first full area short MCFC stack.
  - Test first cells with advanced integrated components.
  - Test molten carbonate fuel cell on actual coal gas.
  - Initiate DOE support of integrated program (EPRI) for molten carbonate internal reforming fuel cell technology.
- FY 1984 Administration's Request to Congress ($5,000)
  - Fabricate and test first full area short MCFC stack.
  - Test first cells with advanced integrated components.

Phosphoric Acid Systems Development

- FY 1984 DOE Request to OMB ($8,000)
  - UTC electric utility powerplant - continue testing on a 20 cell full size (10 ft^2) subscale stack to complete stack technology verification. These are the high performance stacks (120 psia, 405°F).
  - Westinghouse electric utility powerplant - initiate endurance testing of a 25 kW subscale gas-cooled stack.

- FY 1984 Administration's Request to Congress ($3,000)
  - Continue the electric utility R&D subscale stack tests.

Question 2: What is the status of the 4.8 MW fuel cell prototype project in New York City? When will the full test program, as originally conceived, be completed?

Answer: The 4.8 MW preprototype power plant in New York has been undergoing check-out tests prior to connection of the fuel cell modules. These tests were interrupted on February 10, 1983 due to discovery of a crack in an external unpressurized duct. Assuming the ongoing investigation and repair is straightforward and no further major problems are encountered, electric power generation should begin in June 1983. The currently planned test program is scheduled for completion in late FY 1983 with the accumulation of about 1000 test hours. Prior schedules projected testing through April 1985. Barring unforeseen problems, the project is now fully funded to completion.

Question 3: Will the $3.0 million funding level for the phosphoric acid program result in contractor termination?

Answer: Funding at $3.0 million would require termination of the on-site phosphoric acid fuel cell development effort and retention of only one major contractor for electric utility technology development.

Question 4: Is the current level of funding for the fuel cell program consistent with the mandate to demonstrate fuel cells commercially for central power generation required by the Non-Nuclear Energy R&D Act of 1974?

Answer: The current level of funding would provide for completion of the demonstration of the 4.8 MW preprototype electric utility power plant in New York and phase out of Government support for the related development effort at a point where the private sector could proceed with fuel cell commercialization as required by the Act.

HEAT ENGINES

Question 1: The FY 1984 Department budget submission to OMB requested $6.0 million for Heat Engines, but the FY 1984 Congressional budget request was reduced to $1.0 million. For each project under this line item, please provide project title, performer, objectives, and funding level at the $6.0 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Heat Engines (Dollars in thousands)

Dispersed Power Systems

- FY 1984 DOE Request to OMB ($6,000)
  - Investigate advanced cooling concepts, including water cooling, to minimize deposition, erosion, and hot corrosion effects and extend component life.
  - Develop basic combustion design requirements to suppress NO_x formation, ensure combustion stability, define essential cooling requirements, and quantify the influence of fuel conditions in firing coal-slurry fuels in experimental gas turbiue combustor systems.
  - Evaluate candidate airfoil, combustor, and other hot gas path component materials under simulated operating conditions to establish overall durability.
  - Analyze engineering data developed through the airfoil cooling combustion, and materials evaluation activities in relation to fuel quality and fuel physical variables in an effort to identify preferred design and fuel conditions.
  - Perform economic and technical assessments to provide first-order cost-performance trade-off data for several assumed design and operating conditions.
  - Conduct experimental engineering tests to establish basic combustion chamber design requirements in relation to selected fuel quality and physical form variables.
  - Investigate fuel injector design requirements in bench scale engineering test stands to establish essential design data in relation to fuel and generating conditions.
  - Evaluate combustion chamber material candidates, thermal coatings, injector materials and related component fabrication needs.

- Analyze engineering data developed through the combustion, design and materials development activities in relation to fuel conditions in an effort to define basic engine design performance trade-off data.

o FY 1984 Administration's Request to Congress ($1,000)
  - The technology base efforts initiated in FY 1982-1983 period will be completed and a final report including detailed analyses of the data in relation to program goals and providing specific conclusions and recommendations will be prepared and distributed to interested Federal agencies and private sector concerns.

Question 2: What demonstrated private sector interest indicates the feasibility of program termination?

Answer: Principal private sector investment has been in combined cycle power generation based upon an integrated coal gasification system, as exemplified by the Coolwater project in California. In addition to Southern California Edison's Coolwater project, which is validating the gasification/combined cycle concept, there has been additional private sector involvement in this area. Specifically, this technology has been demonstrated in the coal-fired combined cycle gas turbine cogeneration facility in the Federal Republic of Germany (FRG) at the Voelklingen prototype power station. This power station utilizes technology developed by Rocketdyne which utilizes a combination of a fluidized bed combustion unit, a hot air gas turbine, a steam generator with pulverized coal firing, and a flue gas desulfurization plant.

The Department is of the opinion that R&D that has been completed has advanced the state-of-the-art to the point where additional activities sponsored by DOE/FE would not be productive. The data already available is sufficient to allow the private sector to make the appropriate decisions as to the potential commercial application of this particular technology. We do not perceive an incremental benefit becoming available to industry should additional work be conducted in this area. Therefore, the Department believes, in view of the foregoing and considering other FE program priorities, that termination of this program is feasible.

Question 3: Why has research into coal combustion in diesel or turbine engines been abandoned?

Answer: We are continuing research in both areas in FY 1983. Under our present FY 1984 plan, we would reduce our rate of effort while critically reviewing the status of both programs in relation to FY 1985 plans.

UNDERGROUND COAL GASIFICATION

Question 1: How does the $1.3 million funding level for the controlled retraction injection point program potentially impact planned efforts by the State of Washington and the Gas Research Institute? How much of these funds will remain in-house at LETC?

Answer: The $1.3 million of FY 1984 funds for the CRIP test should be sufficient to allow post burn coring and evaluation of the CRIP test site and incorporation of this data into the computer tape data base which contains the information on all DOE sponsored UCG tests. No funds will be available for a follow-on proof-of-concept test planned by the cooperating industrial partners. GRI has been cost sharing the UCG technology base effort at about $1 million per year but have reduced their contribution in line with DOE reductions. Less than $100,000 of the $1.3 million will be spent in-house at LETC.

Question 2: Will the $700,000 for FY 1984 complete the DOE commitment for environmental monitoring?

Answer: This depends entirely on the results of the monitoring. It appears that active restoration of underground water at the Hoe Creek site may be required. If so, the required funding for FY 1984 to accomplish these tasks would be re-evaluated.

MAGNETOHYDRODYNAMICS (MHD)

Question 1: Why have FY 1983 appropriated funds been directed toward phase out of the MHD program, where there has been no Congressional direction to do so?

Answer: While no FY 1983 funds have been directed toward the phase out of the MHD program to date, the Department of Energy is planning to phase out the operation of the test facilities and bring the component development activities to an orderly conclusion in FY 1983. Prior to taking such action, we would notify Congress.

MAGNETOHYDRODYNAMICS (MHD)

Question 2: What are the FY 1982 and FY 1983 operating expenses for the CDIF, CFFF, and LORHO facilities?

Answer: The FY 1982 and FY 1983 operating expenses for the CDIF, CFFF and HPDE (formerly LORHO) are as follows:

Facility	FY 1982 (Actual)	FY 1983 (Planned)
CDIF	$7,150,000	$7,600,000
CFFF	4,400,000	5,600,000
HPDE	1,000,000	633,900

SURFACE COAL GASIFICATION

Question 1: The FY 1984 Department budget submission to OMB requested $27.04 million for Surface Coal Gasification, but the FY 1984 Congressional budget request was reduced to $16.9 million. For each project under this line item, please provide project title, performer, objectives, and funding level at the $27.04 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Surface Coal Gasification (Dollars in thousands)

Advanced Process Development

- FY 1984 DOE Request to OMB ($4,950)
  - Continue high priority projects that have the greatest contribution to the technology data base including fundamental gasification studies, tests involving advanced gasification reactors, modeling, advanced waste water treatment studies, research on low rank coals, and other promising technologies.

- FY 1984 Administration's Request to Congress($4,000)
  - Continue tests on selective advanced entrained-bed and fluidized-bed reactor systems; perform limited studies in the areas of modeling, waste water treatment, and fundamental studies on coal gasification.

Systems Engineering Concepts

- FY 1984 DOE Request to OMB ($15,650)
  - Continue support of several key gasifier fixed-bed, fliud-bed, entrained data base studies essential to technology transfer and advancing state-of-the-art.
  - Continue efforts to resolve state-of-the-art instrument and equipment problems and to increase gasifier systems reliability.

- FY 1984 Administration's Request to Congress ($6,900)
  - Continue support of fixed bed gasifier systems data base studies essential to technology transfer and advancing state-of-the-art.
  - Continue efforts to resolve state-of-the-art instrument and equipment problems and to increase gasifier systems reliability.

Environmental and Engineering Analyses

- FY 1984 DOE Request to OMB ($3,400)
  - Continue only high priority projects having potential to provide solutions to problems identified as being technology limiting.
  - Continue efforts to determine the capabilities and limitations of cleanup systems and the environmental impact of zero waste discharge requirements.

- FY 1984 Administration's Request to Congress ($3,000)
  - Same as DOE Request to OMB but at a reduced level of effort for all projects.

SURFACE COAL GASIFICATION

Question 2: Specifically, how will the FY 1984 request affect the status of the Waltz Mill fluid bed gasification project, the Mountain Fuels entrained bed gasifier, and the Homer City Bi-Gas PDU?

Answer: The FY 1984 budget does not request funds to support the continued operation of these three projects. As a result, the activities on these projects will be concluded during the FY 1983 - FY 1984 time period. The specific status of each project is as follows:

- Waltz Mill Fluidized Bed Gasification Project - Sufficient funds were provided in the FY 1983 budget to fund the Government share of the program to complete an environmental assessment run, investigate additional coals and gather fundamental data leading to an understanding of the parameters that control agglomeration of coal and/or prevent the formation of clinkers in fluidized bed systems. This work will be completed by mid-1984 and the major technical objectives in the development of this concept (pressurized ash agglomeration) of coal gasification will be achieved.
- Mountain Fuels Entrained Bed Gasifier - This project is proceeding essentially on schedule and within costs. As a result, the technical objectives of this cofunded effort will be achieved as planned under the existing contract. Sufficient funds were provided in FY 1983 to fully fund the Government's share of the contract. Contractual work is expected to be completed in mid FY 1984 and additional funds are not required.
- Homer City Bi-Gas Pilot Plant - Additional funds were appropriated in FY 1983 to continue the operation of the facility and complete the technical development effort. Concurrent with this operational program, and in response to congressional direction, a study was initiated to evaluate the feasibility of converting this pilot plant into a test facility for gasification. The results of this study are required to determine what role, if any, the Bi-Gas pilot plant should have in the continued development of gasification technology. Since sufficient funds were provided in FY 1983 to complete the technical program, close the facility, and place it in a protected stand-by status, no FY 1984 funds were requested.

SURFACE COAL GASIFICATION

Question 3: Regarding the Systems Engineering concepts request, what funding levels will be allocated to the Argonne National Lab and Morgantown ETC?

Answer: A total of $6.9 million is requested in the FY 1984 budget under the Systems Engineering Concepts program. The preliminary estimates for the allocation to Argonne National Laboratory (ANL) and Morgantown Energy Technology Center (METC) are about $0.9 million for ANL and about $3.6 million for METC.

UNCONVENTIONAL GAS RECOVERY

Question 1: The FY 1984 Department budget submission to OMB requested $11.0 million for Unconventional Gas Recovery, but the FY 1984 Congressional budget request was reduced to $5.0 million. For each project under this line item, please provide project title, performer, objectives, and funding level at the $11.0 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Unconventional Gas Recovery (Dollars in thousands)

Eastern Gas Shales

- FY 1984 DOE Request to OMB ($2,000)
  - Expand the technology base in support of development of a mineback facility.
- FY 1984 Administration's Request to Congress ($1,000)
  - Continue integration of all shale data into the Eastern Gas Shales projects data base.

Western Tight Gas Sands

- FY 1984 DOE Request to OMB ($5,000)
  - Continue multi-well experiment and supporting research.
- FY 1984 Administration's Request to Congress ($3,000)
  - Continue, at a reduced level of effort, the multi-well experiment and supporting research including field testing and data analysis.

Geopressured Methane

- FY 1984 DOE Request to OMB ($2,000)
  - Continue engineering analysis and supporting research.
- FY 1984 Administration's Request to Congress ($0)

Environmental and Advanced Research

- FY 1984 DOE Request to OMB ($2,000)
  - Initiate hydrate and abiogenic resource evaluation and verify coalbed/methane fracture model.

- FY 1984 Administration's Request to Congress ($1,000)
  - Characterization of gas resource potential of methane hydrates and deep source (abiogenic) gas, as well as data analysis of environmental assessments.

Question 2: What is the proposed status of the Eastern mineback facility in the FY 1984 program?

Answer: Fossil Energy's FY 1984 program is aimed at the development of a technology knowledge base to assist the Gas Research Institute in a subsequent decision to establish and select such a test facility. This action is limited to research, data analysis, and technical consultation with the Gas Research Institute and also in the assessment of industry needs. Ownership of and funding for such a mine test facility is expected to be the responsibility of the Gas Research Institute. Actual start up of the facility is not expected before FY 1985.

Question 3: In regard to the Western tight gas sands program, when was the third test well completed? What is the role for Sandia National Laboratory in this effort?

Answer: The third well of the Multi-well Experiment has not been drilled. Present plans are for the well to be started in late May of 1983. The well should be completed by the end of July 1983.

Sandia National Laboratory is DOE's prime contractor for the Western Gas Sands Multi-well Experiment. They are responsible for all activities associated with the experiment. This includes all drilling, testing, and stimulation activities. Much of the work is sub-contracted by Sandia to other performers.

UNCONVENTIONAL GAS RECOVERY

Question 4: In the submission to OMB, funds were requested for geopressured resource R&D. Was this work a continuation of activities transferred from the geothermal program or new starts? Please describe them.

Answer: The technical goals of the FE proposal focus on the nature of the geopressured aquifers as an unconventional gas resource, an extrapolation and focusing of the original broad goals of the aquifer program within the Geothermal Program. In previous years, the program approached the aquifer questions with a broad series of very expensive field tests in scattered wells of opportunity and design wells, as well as a generic R&D support program. The result has been a very large volume of field and laboratory data, but very little in the way of resource definition or any systematic reduction of the economic and technical uncertainties surrounding production of the gas resource.

The FY 1984 program proposal to OMB included Design Well testing at one site, and the analysis and correlation of test data from past field experiments. This information would be used in an investigation of the need for improved recovery methods. Also proposed was the design of sand control techniques to permit higher brine flow rates to enter the well bore. Basic research, such as a study on the impacts of gas coning effects on recovery, was proposed in addition to modeling to quantify parameters for predictive capabilities. Based on existing and incoming data, site specific reserve estimates and economics analyses of recovery studies would be developed.

ADVANCED PROCESS TECHNOLOGY

Questions 1: The FY 1984 Department budget submission to OMB requested $6 million for the APT program, but the FY 1984 Congressional budget request was reduced to $2.9 million. Please provide project title, performer, objectives, and funding level of work planned for at the $6 million request and the $2.9 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Advanced Process Technology (Dollars in thousands)

Advanced Exploratory Research

- FY 1984 DOE Request to OMB ($5,000)
  - Evaluate innovative petroleum production and extraction concepts, e.g., microbial EOR field testing.
  - Develop data base related to chemical and physical phenomena underlying processes being developed, i.e., processes for demetalization of heavy oils and shale oil, thermodynamic properties of organic nitrogen compounds in heavy oil and shale oil, and evaluation of stability of heavy oil and shale oil.
  - Maintain existing data base on crude oil, shale oil and products including the characterization of the heavy ends of petroleum and shale oil.
  - Delivery of small and varied quantity of synfuel products.

- FY 1984 Administration's Request to Congress ($2,150)
  - Continue, but at a reduced level, basic research into microbial EOR, separation techniques development, crude oil analyses, instrumentation and technique development, and storage/handling fuel stability studies regarding petroleum products and resources.
  - Perform basic characterization research on Cerro Negro heavy crudes under a cooperative agreement with Venezuela.

Arctic and Offshore Research

- FY 1984 DOE Request to OMB ($1,000)
  - Improve existing instrumentation and sensors for use in severe and/or remote environments.

- Better quantification and understanding of properties and characteristics of ice and the effects of ice and ice forces on structures.
- Determine fundamental engineering properties of submarine soils.
- Advanced technology for use in deep water.
- Standardize the collection, reduction, correlation and analysis of data to establish a uniform data base of Arctic/offshore environmental data.

- FY 1984 Administration's Request to Congress ($750)
  - Continue monitoring and coordinating role for energy-related Government Arctic research activities.
  - Reduce direct support of specific research studies in fundamental areas such as seafloor engineering, sea-ice dynamics, and environmental issues of oil spill phenomena and of atmospheric pollutants.

Question 2: Why did the Department submission to OMB request a funding increase over the FY 1983 appropriation?

Answer: The increase in funding for the Advanced Exploratory Research (AER) activity reflected the crosscutting nature of the AER activity in support of the heavy oil, tar sands, oil shale, and coal liquids programs. As these extraction technology programs near fruition, additional AER support was envisioned to perform the fundamental petroleum chemistry, advanced processing, and advanced utilization efforts to support these extraction research programs. Also, full field testing of microbial EOR was being planned for FY 1984.

Question 3: Please provide a breakdown of projects in the Advanced Exploratory Research activity, including the performers, objectives, and funding levels.

Answer: The information requested has been provided in response to Question 1 of the Advanced Process Technology section.

ADVANCED PROCESS TECHNOLOGY

Question 4: What will be done with the $750,000 requested for Arctic and offshore research?

Answer: DOE will conduct fundamental research to better understand Arctic ice mechanics, sea floor stability, and other harsh climatic and environmental conditions impacting oil and gas operations. The engineering design of specific rigs and equipment will be left to industry. The FY 1984 Arctic research activity envisioned by DOE will not involve expensive full field testing. Such full field testing in the Arctic could require 50 or 100 fold the funds requested. We will focus on collection and analysis of existing data and information and the development of models for predictive purposes.

It must be remembered also that other Federal Agencies (Interior, NOAA, EPA, DOD, Coast Guard) are conducting related Arctic research programs. Thus, DOE's funding request only represents a small part of the total Federal Arctic research effort. We will attempt to work closely with these efforts so that overall energy-related needs are being met in a coordinated manner.

ENHANCED OIL RECOVERY

Question 1: This is the only area in FE with a requested increase (+42% over FY 1983). Why shouldn't the industry be more willing to support R&D in EOR, particularly in heavy and light oil subactivities?

Answer: Industry is doing research and implementation of new petroleum projects at a pace consistent with their needs and the availability of financing. Current enhanced recovery techniques such as polymer and steam flooding are being started by industry whenever justified by technical factors and economics.

Some of the more advanced EOR techniques are not widely used today because further development is required to improve their reliability. The Government has an appropriate role in doing the basic and fundamental research needed to better understand and predict the performance of these advanced techniques. This improved understanding, we believe, will lead to new processes that are economically competitive, but it will be industry that ultimately decides whether it makes financial sense to deploy these new processes in commercial use.

We believe that the Government role should be that of a catalyst. By doing fundamental research on theoretical aspects and modeling of techniques for enhanced oil recovery, we hope to provide a sufficient technical foundation in critical areas for industry to design, scale-up and deploy new petroleum recovery processes on their own.

It is generally not in the interest of the oil industry (and beyond the capability of many independent oil companies) to expend funds for the long-term R&D required to develop new or improved technology which would maxamize resource recovery. Their interest is, in general, to maximize near-term to mid-term profitability through short-term low-risk R&D.

ENHANCED OIL RECOVERY

Question 2: Please provide a list of projects including performers, objectives, and funding levels for each subactivity in EOR.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Enhanced Oil Recovery (Dollars in thousands)

Heavy Oil

- FY 1984 DOE Request to OMB ($4,300)
  - Initiate studies on the effect of noncondensable gases with steam relative to improved oil recovery.
  - Perform post-flood analyses of City of Long Beach and Aminoil's caustic floods.
  - Analyze results of controlled source and HFEM tracking results for an in situ combustion and/or steam recovery project.
  - Complete the mathematical model for fuel deposition and related parameters of the in situ combustion process.
  - Complete studies on the effects of pressure and/or temperature on reservoir parameters.
  - Complete survey and analysis of potential techniques for determining steam quality and initiate development of test equipment of selected techniques.
  - Begin combustion tube tests to determine the effect of using oxygen injection as an alternative to air injection on the kinetics of the in situ combustion process and model the results.
  - Continue technology exchange with Mexico and Venezuela.
- FY 1984 Administration's Request to Congress ($3,700)
  - Same as DOE Request to OMB but at a reduced level of effort.

Light Oil

- FY 1984 DOE Request to OMB ($7,000)
  - Continue chemical and miscible gas flooding R&D consisting of fundamental research on displacement mechanisms and advanced recovery processes; EOR data base analysis related to FE and ERA-incentive tests.
  - Expand research on rock-fluid interactions in chemical flooding; miscible gas plus additives development; EOR data base extension and post-test analyses.

- FY 1984 Administration's Request to Congress ($6,550)
  - Same as DOE Request to OMB but at a reduced level of effort.

Tar Sands

- FY 1984 DOE Request to OMB Budget ($1,000)
  - Same as Administration's Request to Congress.

- FY 1984 Administration's Request to Congress ($1,000)
  - Continue R&D efforts into displacement mechanisms, forward and reverse in situ combustion methods, hot fluid injection such as cyclic steaming and steam flooding, tar sand mining, environmental research for both air and water quality, and alternate extraction technologies.
  - Continue technology exchange agreements with Canada.

OIL SHALE

Question 1: The FY 1984 Department budget submission to OMB requested $12.9 million, but the FY 1984 Congressional budget request was reduced to $8.6 million. Please provide project title, performer, objectives, and funding level of work planned for at the $12.9 million request and at the $8.6 million request.

Answer: Specific performers are not listed because final determination has not been made relative to selection of new or continuation of existing performers as well as amounts for each. The objectives and funding levels for both the FY 1984 DOE request to OMB and the Administration's request to Congress follow:

Oil Shale (Dollars in thousands)

Oil Shale Technology Base

- FY 1984 DOE Request to OMB ($6,400)
  - Continue laboratory research on chemistry and kinetics of shale conversion. Included in this activity would be development of additional generic surface process models for system and subsystem evaluation.
  - Materials transport research, completion of evaluation of fracture test series, new laboratory research in support of fracture modeling and diagnostics, tests of hypotheses for new concepts.
  - Monitoring of eastern shale projects.
  - ASPEN-Type process evaluation.

- FY 1984 Administration's Request to Congress ($4,300)
  - Laboratory research on chemistry and kinetics of shale conversion will be stretched out.
  - Continue evaluation of explosive fracture tests to provide guidance for new laboratory experiments.
  - Completion of evaluation of fracture test series, new laboratory research in support of fracture modeling and diagnostics will be stretched out.
  - Complete innovative concept studies regarding Eastern shales.

Environmental Mitigation

- FY 1984 DOE Request to OMB ($6,500)
  - Continue laboratory research on chemistry and cleanup of water and air pollutants from retorting and maintain compliance activities. Included in this research will be additional large-volume water treatment experiments.

- Effects of process parameters on pollutant emissions, evaluation of data, and implementation of control technology tests at field sites.
- Develop data to assist industry to mitigate problems regarding air emission control procedures, water management systems, and solid waste management strategies.

o FY 1984 Administration's Request to Congress ($4,300)
  - Stretch out laboratory research on chemistry and cleanup of water and air pollutants from retorting and maintain compliance activities.
  - Evaluate the effects, over a longer time period, of process parameters on pollutant emissions, evaluate data, and implement control technology tests at laboratory-scale level.
  - Develop data, over a longer time period, to assist industry to mitigate problems regarding air emission control procedures, water management systems, and solid waste management strategies. Transfer retort abandonment models completed in FY 1983 to industry.

Question 2: How much funding does Laramie receive in FY 1983 and FY 1984? Please provide similar information for National Labs.

Answer: It is anticipated that the Laramie Energy Technology Center (LETC) will receive $6,495,000 in FY 1983 and $4,000,000 in FY 1984.

The FY 1984 data is based on very preliminary estimates and is subject to adjustments based on the completion of a negotiated cooperative agreement with the University of Wyoming for the continuation of the research and development program at LETC.

The attached table provides the funding profile of the Oil Shale program as it is proposed to be distributed to the National Labs based on our initial planning for FY 1984.

DEPARTMENT OF ENERGY
FY 1984 CONGRESSIONAL BUDGET REQUEST
ESTIMATE FOR LABORATORIES AND PLANTS - WORKSHEET

OIL SHALE
(In Thousands of Dollars)

CONTRACTORS	FY 1982 Estimate		FY 1983 Estimate		FY 1984 Estimate	
	OBS	B/O	OBS	B/O	OBS	B/O
Operating Expenses:						
National Laboratories						
Argonne National Laboratory	0	32	0	0	0	0
Lawrence Berkeley Laboratory	300	355	600	525	421	466
Lawrence Livermore National Lab.	3,480	3,164	1,500	1,995	1,053	1,165
Los Alamos Scientific Laboratory	1,765	1,803	1,300	1,416	913	1,009
Pacific Northwest Laboratory	0	0	200	150	140	155
Sandia Laboratory	3,062	3,129	1,315	1,752	923	1,021
Subtotal	8,607	8,483	4,915	5,838	3,450	3,816
Capital Equipment:						
Lawrence Berkeley Laboratory	58	47	0	11	0	0
Lawrence Livermore National Lab.	154	364	0	0	0	0
Los Alamos Scientific Lab.	221	115	0	106	0	0
Sandia Laboratory	269	140	0	562	0	0
Subtotal	702	666	0	679	0	0
TOTAL Oil Shale	9,309	9,149	4,915	6,517	3,450	3,816

OIL SHALE

Question 3: Who will conduct the series of tests in the low-void test facility?

Answer: The work will be performed under the cooperative agreement that is being negotiated with the University of Wyoming to operate the LETC facilities.

Question 4: Are all the technology base activities directed toward in-situ retorts? Please explain.

Answer: Approximately one-half of the technology base activities are specific to completing the data base development for in situ processing. This work includes:

1. establishing the criteria for fracture/void requirements that will provide oil yields with the lowest mining/fracturing requirements, as a guide to the fracturing research area;
2. verifying the fracture damage zone prediction capability of present DOE models;
3. extending these models to incorporate the effects of explosive gases in moving fractured particles to create a rubble bed;
4. developing/evaluating tracer techniques for measuring the distribution of "active" void volume (that which is open to transmission of gases and liquids); and verifying the predictive capability of a DOE developed 2-dimensional model of the retorting process.

Some present research on chemistry and physics of oil shale processing is completely generic in nature (of equal value to improved understanding of surface and in situ processes) such as developing physical descriptions for the formation and deposition of suspended oil mist with drainage and recurrent distillation of product oil, reaction kinetics of shale oil coking, reaction kinetics of combustion of gases and hydrocarbon vapors to predict oil yield losses, and development of a detailed chemical and kinetic description of kerogen decomposition to identify more specific chemical indicators or retorting performance. Also completely generic is research to develop sampling and analytical methods for real-time measurements of retort performance to control operating conditions of laboratory retorting experiments.

Generic chemical research that is most applicable to surface processing includes development and application of spectroscopic techniques to distinguish between aliphatic and aromatic carbon in oil shale to evaluate conversion of aromatic carbon in combustion and gasification reactions (particularly important for eastern shales) and to predict relative reactivities of different oil shales with hydrogen. Also, surface processing oriented is research to determine the chemical structures associated with heteroatoms in kerogens by spectroscopic techniques and then to determine if selective oxidation of these species in kerogens will reduce their content in the primary products from thermal processing.

Mr. **Fuqua**. Thank you very much.

You signed agreements on February 28 with the University of North Dakota and the University of Wyoming relating to the energy technology centers. What happens to the employees that are there?

Mr. **Mares**. The employees at each center will be RIF'ed, and employment opportunities by the new operator will be offered to them. In fact, at the University of North Dakota, essentially all of the employees have been offered employment by the University of North Dakota. The employees have not been notified of a RIF as of this moment.

Mr. **Fuqua**. In either of the places?

Mr. **Mares**. At neither of the places. At the University of North Dakota, essentially all the employees have been offered employment by that university.

I think the university is really very enthusiastic and looks upon this as an opportunity to expand the horizons of that facility beyond what could have happened. They are looking to use the capability of the center not only as an addition to their engineering department, but also to do work for other entities, non-Federal entities.

Mr. **Fuqua**. Why is it necessary to RIF them, then, if they are all being offered, I assume, comparable jobs with the university or the new operating agency?

Mr. **Mares**. The jobs are essentially comparable. RIF procedures are used in conformance with Office of Personnel Management policy to insure that employees' rights are protected in competing for the remaining Federal positions irrespective of whether such employees are offered comparable jobs with the university. As you remember, when we started discussing this a year ago, we reached a judgment over the last several years that we were not utilizing those facilities or those people—and they are a very precious resource to this country—anywhere near their capability. In fact, in several cases, we have been decreasing the funding at the center.

I made a judgment when I looked at that resource that there was a better way to use that in the Nation's best interests rather than simply continuing it in the same way that had been done in the past.

So I talked with the presidents of each of those universities and determined that they had needs that our employees could fulfill. In the case of the University of North Dakota, they had needs in education. It was also clear that there would be other people that would like to use the services of those facilities. By so doing, our expectation is that there will be more work at those centers than if we had continued solely as a fossil energy facility.

Mr. **Fuqua**. What does this do to your personnel floor? Is it reduced by that amount that you RIF'ed for the two places?

Mr. **Mares**. Well, the only floor that is meaningful is the law, sir. This in no way jeopardizes our ability to comply with the law.

Mr. **Fuqua**. How many people are employed at the two centers combined?

Mr. **Mares**. There are about 65 Federal employees at Grand Forks and about 120 at Laramie.

Mr. FUQUA. Will your personnel ceiling be reduced by an equal number?

Mr. MARES. Well, as I say, the ceiling that is relevant is the law. We are charged with complying with the law, and I am sorry that I cannot tell you that we are in fact complying with the law right now at headquarters or at Morgantown. We are trying in each case to build the staff to the level that the law requires.

But the remainder of the law in no way limits us, in terms of the number of personnel we will have on board, from the proposed actions at Laramie and at Grand Forks.

Mr. FUQUA. Could you transfer those slots in somewhere else?

Mr. MARES. I am sorry. I don't follow the thrust of your question, sir.

Mr. FUQUA. Let's say you have 125 people, the combined Federal employees at both centers, and you RIF 125 people; then you have 125 slots that you can use somewhere else, right?

Mr. MARES. If one reached the judgment that that was necessary in order to deliver an outstanding fossil energy program.

Mr. FUQUA. But you could, though?

Mr. MARES. Yes, sir.

Mr. FUQUA. Then you could transfer them somewhere else?

Mr. MARES. Well, there is nothing that I am aware of in the law that would prevent that; no, sir.

Mr. FUQUA. Right. And you don't have to fill them, either.

Mr. MARES. That is also correct. My obligation is to have a staff—I believe the number was a minimum of 754—which, with all due respect, I think, does make management of the fossil energy program more difficult than need be. But that is the law, and we are trying to comply with it.

There were no floors in the law in the three western centers, Bartlesville, Laramie, or Grand Forks.

Mr. FUQUA. What is the status of Bartlesville? You say you are receiving bids until March 18.

Mr. MARES. Well, a request for proposals was sent out by the Department on about January 8, and copies of that were made available to all of the committees here. The request was for proposals originally to be due on March 4. The Source Evaluation Board has extended that until March 18.

Our expectation is that there will be more than one qualified bidder who will make a proposal to operate that facility. The facility would continue to be owned by the Federal Government. The request was for an operator to operate it for a period of 5 years with decreasing Federal funding each year.

Again, the operator would have the opportunity to work for others as well as for the Federal Government. There, too, I am very much convinced that there is a great opportunity for that facility and the people there, with their capabilities, to do meaningful, valuable work for the country, not only for the Office of Fossil Energy but for other entities in this country.

This will provide that opportunity in a way that we cannot do it in our current format.

Mr. FUQUA. Is the Interstate Oil Compact Commission one of the viable candidates?

Mr. Mares. The decision as to whether anybody is a viable candidate or not is one that is to be made by the Source Evaluation Board based upon their evaluations and any advice that they are given.

I understand there has been a request for the GAO to determine whether the Interstate Oil Compact Commission could be a viable candidate. I have every confidence that the Source Evaluation Board will take that into account.

I am not now a member of the Source Evaluation Board, although I was for a period of time. Also, I am not an adviser to the Source Evaluation Board. It is inappropriate for me to have any communications with them of any nature.

In the final analysis, it will be their decision, based on the advice they get from counsel, as to whether the IOCC is a qualified bidder, and it will not be until the 18th of March before they will know who in fact has made bids in response to the request for proposals.

Mr. Fuqua. You referred to a chart during the course of your testimony. You have $138 million that has been approved and recommended by OMB. How much did DOE ask OMB for?

Mr. Mares. Well, first I would say that what we are suggesting, sir, is the administration's proposal, and——

Mr. Fuqua. I know, and I know you are to defend that, and you do a good job.

I am asking, how much did DOE request? Didn't you request $100 million more than that?

Mr. Mares. The departmental request in September for fossil energy was $238 million.

Mr. Fuqua. And OMB reduced it by $100 million?

Mr. Mares. When all of the requests, both for this department as well as other departments, were evaluated, the judgment was made that $138 million was an appropriate level considering all the needs.

I might point out that in all of my own personal experience, both before I came here as a manager, as well as here, I have requested people working for me to give requests in excess of what I thought we would finally have, and that is a very sound management technique because it gives the manager the chance to weigh one program versus another.

I think what has gone on is a very sensible program of evaluating various requests and trying to come up with an overall balance to meet the various needs of this country.

Mr. Fuqua. What was the request that came in to DOE from the various centers and laboratories, and so forth, that you whittled down to $238 million?

Mr. Mares. I have not gone back and added that up or evaluated it, but it was in excess of $238 million.

Mr. Fuqua. Do you have evidence that industry is picking up the process development and commercialization of the proof of concept programs? Do you have some examples of where industry has moved in and picked up these programs?

Mr. Mares. I think an example of one that we have nurtured that has made some progress commercially is the Westinghouse gasifier. They have a relationship that they have developed with

SASOL in South Africa that ought to stand them in good stead. I think they are quite pleased about that.

That is also a gasifier which is being considered in a project which I believe is going to be put before the SFC if it has not already been put before the SFC. I think that is a clear example.

I think that the atmospheric fluidized bed industry which exists today, where there are 20 boiler manufacturers who are selling atmospheric fluidized bed systems for industrial use, is a clear example where there have been concepts which have been developed with Federal funds which are not out in the commercial sector.

The down-hole steam generator idea is being marketed by at least two firms for use in generating steam for enhanced oil recovery.

So I think there are several cases where that in fact has happened.

Mr. **Fuqua**. Has EPRI finalized its plans for the Wilsonville facility?

Mr. **Mares**. I do not believe that they have, sir.

Mr. **Fuqua**. Pardon?

Mr. **Mares**. I do not believe that they have finalized their plans. No, sir, I do not. If they have, I am unaware of it.

Mr. **Fuqua**. You have $4 million requested for indirect liquefaction. How much of that is for the methanol-to-gasoline project in Germany?

Mr. **Mares**. About $1 million, which would be our last installment on that project. My understanding is that we will be completing that in fiscal year 1984.

Mr. **Fuqua**. And you do not include funding for the liquid phase of the methanol project with Air Products in this year?

Mr. **Mares**. No, sir, that has not been included. However, I am optimistic that we will be able to negotiate a transfer of that facility to Air Products, because I think that they will see that we have come far enough in the technology development to allow them to carry it on from here.

Mr. **Fuqua**. How much do we have invested in that facility?

Mr. **Mares**. I think, in the facility itself, it is less than $10 million, but there has been over that in the total program. I would rather supply it for the record, sir.

Mr. **Fuqua**. All right.

[The information follows:]

TOTAL INVESTMENT IN THE LIQUID PHASE METHANOL PDU, LA PORTE, TEX.

To date, DOE has obligated a total of $6,075,000 for the liquid phase methanol PDU located at La Porte, Texas. The total investment in this project, including cost share by Air Products Co., is $7,123,000. DOE has available and unobligated from fiscal year 1983 appropriations a total of $2,200,000 that is to be applied to this project.

Mr. **Mares**. As I recollect, that was a facility that was originally designed for a different purpose and has been modified in order to perform this particular series of tests.

Mr. **Fuqua**. Are there any plans to operate the facility under this agreement?

Mr. **Mares**. Well, that would be one of the things that would obviously be subject to negotiation with them in terms of what will be the use of the facility. The title to the facility is with the Government at this stage. It also would be one of the subjects of negotiation.

Mr. **Fuqua**. Is Air Products going to operate it themselves?

Mr. **Mares**. They certainly have the technical capability to do so.

Mr. **Fuqua**. I know, but are they going to do that, though?

Mr. **Mares**. Well, I am sure we have not completed the negotiations, and I do not know how far along into them we are as of this stage. We are in preliminary discussions.

Mr. **Fuqua**. What would be the cost? We have spent about $10 million, and apparently there is a good chance it may not even be operated. What would it cost to operate it for a year or 2 years to prove the concept?

Mr. **Mares**. My recollection is the operating cost was about $4 to $5 million for a year.

Mr. **Fuqua**. For 1 year?

Mr. **Mares**. Yes, sir.

Mr. **Fuqua**. The technology based activities in oil shale are directed toward the in situ retorts. How much of the technology to date has tended to suggest that the original promise of the in situ recovery process probably will not materialize?

Mr. **Mares**. Let's see if I can repeat your question. How much of the work that we have done to date suggests that the original promise will not materialize?

Mr. **Fuqua**. Yes, will not work.

Mr. **Mares**. I think that is ultimately for the marketplace to decide. Let me tell you at least a couple of things——

Mr. **Fuqua**. Have you got any data? That is what I am asking.

Mr. **Mares**. Well, I think there are a couple of things that have been determined technically relevant. One is that in the last burn at Logan Wash of the occidental project, when they were able to collect and analyze more carefully the vapor effluent, their material balance turned out to be much better than they had been experiencing. I recollect that they had an over-50-percent recovery. Of that I am certain.

My recollection also is that there has been in the oil shale proposal to the SFC at least one that is in situ technology. That would tell me that there is judgment by people who are willing to put their own money on the line that there is some promise for that technology.

But I can supply for the record specifically what has been applied to SFC, as well as what will be—we cannot tell you before it happens, but after the 15th, we would certainly advise you of whether there are any in situ proposals at SFC.

Mr. **Fuqua**. Would you provide that, please.

[The information follows:]

In Situ Oil Shale Proposals to SFC

The Cathedral Bluffs Project, Rio Blanco County, Colorado, a partnership of Occidental Oil Shale, Inc., and Tenneco Shale Oil Company, has proposed options combining in situ retorting with surface retorting using Union's Unishale B retort, under both the third round solicitation and the directed oil shale solicitation. Their preferred option would initially use one Unishale B retort producing 11,100 b/d combined with in situ production of 2,400 b/d.

Geokinetics Incorporated has proposed two in situ projects to the SFC under the third round solicitation, the Seep Ridge Project and the Wolf Den Project, both located in Uintah County, Utah. Seep Ridge would start this year with production targeted at 1,000 b/d. Wolf Den would begin construction in 1984, to begin production in 1987, with a target level of 4,000 b/d.

The SFC has recently announced selection of the Cathedral Bluffs Project and the Seep Ridge Project for Phase II negotiations, both projects having passed the financial maturity and technical strength reviews.

Mr. FUQUA. What is the status of the fuel cell project in New York City?

Mr. MARES. It is in extended start-up. I would have to say it has taken longer to get it started than I think anybody would have liked. It is not at all uncommon when you start up new technologies that things happen that you do not expect, and more of those have happened than we expected, but we are optimistic that we will conclude the work in that this year.

Mr. FUQUA. Are there funds in fiscal year 1984 for that?

Mr. MARES. No. Our conclusion and judgment is that we will not need funds in fiscal year 1984.

Mr. FUQUA. But you will have enough pipeline funds to get it operating?

Mr. MARES. We expect to complete successfully the work we set out to do with the funds we have to date. Yes, sir.

Mr. FUQUA. Do you have any idea when it might be completed?

Mr. MARES. I think the current forecast to start up is later this spring.

Mr. FUQUA. The end of the extended delay.

Mr. MARES. In June, as I recollect.

Mr. FUQUA. June.

Mr. Lewis?

Mr. LEWIS. Thank you, Mr. Chairman.

Mr. Mares, I get confused sometimes. What do you feel the responsibility of DOE is in working with the private sector to perform the necessary R&D to meet the possibility of the depletion of fossil fuels?

Mr. MARES. I think we can make our greatest contribution by concentrating on the basic science and applied research and communicating the results of that—making them available to the private sector. Also, we attempt to focus our work in that area by taking advantage of the views of the private sector which we solicit in the course of workshops, seminars, conferences, as well as meetings in our office, wherein our people try to learn from leaders of the private sector what their views are of the important research that needs to be done to enhance the technological base of this country.

So I think we try very hard to take into account their views because, in the final analysis, it is going to be the private sector that will take these ideas and ultimately commercialize them for the benefit of this country.

Mr. LEWIS. Well, as far as the up-front funding in order to meet the R&D responsibilities which a lot of free enterprise areas of the private sector cannot meet initially, what is the responsibility of DOE and the Federal Government in that area?

Mr. MARES. Well, I think that the focus of our effort and responsibility is to fund at an appropriate level that research which is sufficiently generic to preclude private sector funding. At the same time, we need to enhance our technology base from a national standpoint.

I think that is our role, and I think we are fulfilling that role.

Mr. **Lewis**. Well, I have a concern in the liquefaction area of your budget, where it looks as if you have reduced your request approximately 58 percent from $41 million down to $17 million. Liquefaction processes are of a high-priority nature, as the chairman brought out, as well as for storage possibilities. Could you explain your reduction.

Mr. **Mares**. Certainly. We have evaluated all of our programs in the context of all of the needs that the Federal Government must satisfy, and our judgment was that it was inappropriate to spend, or to request to spend, in 1984, funds in fossil energy at the same level that they were appropriated in 1983.

When we evaluated the various ways that we could spend funds to enhance the liquid capabilities of the country, we looked at several of those programs, including coal liquefaction, and focused on, within each of the programs, that part that we thought the country would get the greatest value from.

Mr. **Lewis**. From the studies of your department, what sort of prognosis do you have as far as the depletion of fossil fuels, and into what out-year do you feel that we are going to see a severe reduction in the availability of fossil fuels?

Mr. **Mares**. Well, I think the most recent forecast I have seen would contemplate that over 70 percent of the energy that is used in this country through 2020 would be fossil fuel based. This includes gas, oil, shale, and coal. I would foresee that going down from about 90 percent in 1980, and I would expect that a similar trend would occur for many years thereafter.

I think fossil fuels will be an enormously utilized resource in this country for many decades.

Mr. **Lewis**. Well, my concern is—and I feel the scientific reports that have come out over the past 15 years have shown this—a substantial depletion in the availability of fossil fuels. It just is not in the ground.

Mr. **Mares**. Not so for coal, sir, or oil shale.

Mr. **Lewis**. I understand that. You say not for coal and not for shale, but when you reduce the liquefaction request by about 58 percent, don't you think that that could put the research and development areas in jeopardy and set them back anywhere from 5 to 10 years?

Mr. **Mares**. No, sir, I do not.

Mr. **Lewis**. You do not.

Mr. **Mares**. I think that the economic likelihood of our country converting substantial amounts of coal to coal liquids before the turn of the century is rather remote, more remote today than it was 2 years ago.

That is because I think the country has been very successful in reducing its utilization of energy per unit of GNP output. I think that is something that the country's both consumers and industrial firms, have done very well.

And so, I think that it is going to be farther out into the future before the conversion of coal to liquid will be required. That is probably the toughest technical and economic challenge that we have in synfuels.

I think there will be ways other than coal liquefaction that we will achieve getting adequate liquids for this country. Before that, I think that conversion of oil shale to liquid will occur before we convert coal in a substantial way to liquid.

I think we will find that we can extract more petroleum that we know in place. We have produced only a one-third of the petroleum that we have found to date in this country. There have been some fields that we have at least technically shown you can produce over 50 percent. It is an enormous resource that is available to this country that could supply the liquid needs of this Nation in a more economic fashion than converting coal to liquid.

I do not believe that the relative amount of funding and the focus on the technical base in coal conversion to liquids disadvantages the country.

Other things that will increase the amount of available liquids that we are influencing in the Office of Fossil Energy include enhancing our ability to use coal economically and environmentally acceptably in combustion.

I think one of the most exciting things that we are working on is coal-water slurries, which could replace residual oil from being used in boilers today.

I think that there has been a lot of thought given to the relative priorities in the budget, and a recognition of trying to enhance the technical base in this country so that, ultimately, the industry is going to make the choices. It is not our place to make the choices as to which will be the appropriate technologies or the subelements within a technology.

That is one of the reasons we are trying to concentrate on the applied research end rather than getting out into the process development or the commercialization side.

So I think that we have a program which will meet the needs of the country.

Mr. LEWIS. Would you send me a copy of your studies on the depletion of fossil fuels. I would like to know why you feel, as you brought out, that coal liquefaction is certainly of a high priority, long-term nature; but, nonetheless—and you are still saying, and believing, like a lot of other people, that we are going to be able to pump oil out of the ground until some day some miracle happens that will enable us to liquefy coal economically in order to meet the requirements of the consumer.

[The information follows:]

DEPLETION OF FOSSIL FUELS

Any study of the depletion of fossil fuels must recognize that the size of the reserve is not fixed over time. Discoveries add to the reserve, new developments in extraction technology make more of the reserve available and changes in the value of fuel increase the size of the reserve up or down as the value goes up or down.

A most valuable discussion of the impact of these variables, and projected depletion rates through the year 2000, is contained in a DOE report entitled "Energy Projections to the Year 2000," published in August 1982. A copy of that report is attached.

FOSSIL ENERGY COAL LIQUEFACTION FUNDING REDUCTION

As has been noted previously, it is the Department's judgment that there are other technologies that are more advanced than coal liquefaction that will ensure that this country will have adequate supplies of liquid fuels in the future. For instance, there exists a higher probability that oil shale will be converted to liquids on a commercial scale in this country before coal is liquified on a commercial basis. To a large extent, this may be attributed to the economics associated with the technologies. Also, as you know, there is great potential for recovery through enhanced oil recovery techniques of an additional 20 percent of petroleum from known reserves. In addition, we are making significant advances in the use of coal-water slurry mixtures which will allow industry to replace large quantities of fuel oil with those coal-water mixtures. These factors, when taken into consideration in conjunction with other Fossil Energy priorities, have led us to the conclusion that, from a national energy standpoint, we could make those reductions in the Coal Liquefaction R&D budget.

It has been the Department's consistent position that our principal focus should be on basic and applied research. It is in those areas that we are concentrating our efforts and thereby leaving the decisions as to eventual commercialization up to the private sector and the market place. I do not believe that the proposed funding reductions in the Coal Liquefaction program detracts from the ability of industry to evaluate the results of our R&D and make the appropriate decisions as to commercialization.

[The report mentioned above follows:]

Energy Projections to the Year 2000 July 1982 Update

August 1982

U.S. Department of Energy
Office of Policy, Planning and Analysis
Division of Analytical Services
Washington D.C. 20585

PREFACE

This document provides energy projections developed within the U.S. Department of Energy by the Division of Analytical Services. Questions about the contents of this report should be directed to:

John Stanley-Miller
Division of Analytical Services
PE-22 Forrestal
U.S. Department of Energy
Washington, D.C 20585
Telephone (202) 252-5388

Underlying these projections are assumptions about key variables --world oil prices, economic growth, and domestic energy production potential--which are described in this document. The assumptions are based on information available to the Division of Analytical Services through June 1982.

Projecting U.S. energy supply, demand and prices through the year 2000 is by nature a highly uncertain process. These projections try to account for uncertainty by providing alternative scenarios.

Projections should not be viewed as a statement of goals or targets. They represent an analysis of the expected evolution of U.S. energy markets through 2000, given current information and existing policies. As circumstances change in the future, projections will change as well.

TABLE OF CONTENTS

Page

Preface i

Section 1: OVERVIEW (Staff Contact: John Stanley-Miller, 252-5388) 1-1

Section 2: WORLD OIL PRICES (Staff Contact: John Corliss, 252-5388) 2-1

Section 3: DOMESTIC ENERGY PRICES (Staff Contact: John Corliss, 252-5388) 3-1

Section 4: DOMESTIC ENERGY CONSUMPTION (Staff Contact: Mark Nassar, 252-5388) 4-1

Section 5: DOMESTIC OIL, GAS AND SYNTHETICS SUPPLY (Staff Contact: Lee Rogge, 252-5388) 5-1

Section 6: DOMESTIC COAL SUPPLY (Staff Contact: Lee Rogge, 252-5388) 6-1

Section 7: DOMESTIC NUCLEAR SUPPLY (Staff Contact: Lee Rogge, 252-5388) 7-1

Section 8: DOMESTIC RENEWABLES SUPPLY (Staff Contact: Alex Haynes, 252-5388) 8-1

Section 9: DOMESTIC ELECTRICITY SUPPLY (Staff Contact: Alex Haynes, 252-5388) 9-1

SECTION 1: OVERVIEW

This report is an update of the energy projections and analysis presented in a document entitled "Energy Projections to the Year 2000," a technical supplement to the National Energy Policy Plan (NEPP) submitted to Congress in July 1981.[1]

The intention of this volume is not to replicate the text and analysis presented in NEPP, but rather to provide revised projections. Consequently, the format used here focuses on providing self-explanatory tables and figures with a minimum of accompanying text.

Uncertainty underlies any long-term projection. The midrange projections presented here represent our best effort to extrapolate current trends and information into the future. To capture the effect of uncertainty, this document provides a variety of scenarios in which two of the most important and uncertain variables--world oil prices and economic growth--are varied over a wide range. By varying world oil prices and economic growth, this report provides a reasonable range on most energy consumption, production and price variables. However, uncertainty surrounds even those variables that do not change much in response to higher or lower world oil prices and economic growth. Consequently, in using the midrange projections provided here, the user is cautioned that all of the numbers are subject to uncertainty and could easily be incorrect by plus or minus 20 percent or more. The purpose of these projections is not to predict the future, but merely to provide a reasonable and internally consistent base case or starting point for performing energy analysis.

This Administration is dedicated to free-market principles. Market adjustments to future changes are fully expected. This market approach recognizes the uncertainties underlying energy projections and gives fair warning that these projections do not constitute any sort of blueprint for the future that this Administration is committed to pursue at all costs--least of all by direct government intervention. Thus, the projections should be viewed as only one of many inputs in forming expectations about our energy future--an input that is carefully drawn, but is not determinative.

---

[1] Copies available by writing to Division of Analytical Services, PE-22 Forrestal, Washington, D.C 20585.

KEY ASSUMPTIONS

World Oil Prices

- The world oil price scenarios all assume that no major oil supply disruptions occur in the future.
- In 1982, OPEC successfully cuts production to sustain the Saudi Benchmark price of $34 per barrel nominal.
- Prices remain constant in nominal dollars in 1982 and then grow slightly faster than inflation to 1985.
- Between 1984 and 1986 the world market becomes tight due to rising world oil demand which pushes OPEC oil production up to about 26 to 28 million barrels per day. Beyond 1986 prices rise more rapidly reaching about $42.50 per barrel in 1981 dollars by 1990.
- Major uncertainties affecting world oil prices include the rate and amount of world oil demand growth after the current recession; the willingness of OPEC countries to maintain low production ceilings to increase price pressure; the value of the dollar which affects product prices in non-U.S. countries; the rate of change in Iran and Iraq oil production; and the rate of increase in non-OPEC oil and non-oil energy production.

Economic Growth

- We assume that after slight negative growth in 1982, the economy moves into a healthy recovery reaching a long-term economic growth trend by 1985.

TABLE 1-1

KEY ASSUMPTIONS

		PROJECTED			
	1981	1985	1990	1995	2000
WORLD OIL PRICE[1/] (1981 dollars/barrel)					
High	$37.00	$37.00	$57.00	$71.00	$74.00
Midrange	$37.00	$32.50	$42.50	$53.50	$62.00
Low	$37.00	$27.50	$31.50	$41.00	$51.00
U.S. ECONOMIC GROWTH[2/] (%/year from 1981)					
High	--	3.5	3.5	3.2	3.1
Midrange	--	2.7	2.9	2.7	2.5
Low	--	1.8	2.3	2.1	1.9

DOMESTIC ENERGY POLICY

- o Complete decontrol of crude and product petroleum prices in January 1981.
- o Decontrol of natural gas prices according to existing law in the Natural Gas Policy Act of 1978.
- o A focus of Federal R&D efforts on long-term development and away from commercialization.
- o Increased rates of leasing federal lands for energy development.
- o No major changes in current environmental regulations.
- o Continuation of the Synthetic Fuels Corporation at current levels of effort.

[1/] U.S. average refiner acquisition cost of crude oil imports. See Section 2, Table 2-1 for year-by-year values.

[2/] U.S. Gross National Product, see Section 4, Table 4-1 for more detailed information.

U.S. END-USE ENERGY CONSUMPTION

- Table 1-2 summarizes projected fuel use by sector from 1980 to 2000 under midrange world oil price and U.S. economic growth assumptions. Section 4 provides additional detail on U.S. energy consumption.

- The numbers shown for 1980 and 1981 are estimates based on a combination of actual data for fuel subtotals and 1973 to 1978 data and trends for sectoral breakdowns by fuel.

- Although liquids (including products from shale and coal synthetics) and gases are separated in the projections, considerable uncertainty surrounds the split in use between liquids and gases (especially in the industrial sector). Consequently, for planning, the combination of liquid and gas use relative to other fuels is probably a more certain variable than the split of liquid versus gas use within the subtotal.

TABLE 1-2

U.S. END-USE ENERGY CONSUMPTION
(Quadrillion Btu's Per Year)

	1980	1981 1/	PROJECTED 2/			
			1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
RESIDENTIAL/COMMERCIAL	16.5	16.2	16.8	17.4	18.2	19.2
Liquids	4.2	4.0	4.0	3.8	3.6	3.3
Gases	7.6	7.4	7.3	7.4	7.4	7.6
Coal Solids	0.2	0.2	0.2	0.2	0.2	0.2
Renewables	0.2	0.3	0.5	0.6	0.8	0.9
Electricity	4.4	4.4	4.8	5.5	6.3	7.2
INDUSTRIAL	24.3	22.8	25.6	28.2	30.0	31.4
Liquids	8.3	7.3	7.6	8.4	8.3	7.9
Gases	8.4	8.0	9.1	9.5	9.9	10.0
Coal Solids	3.2	3.1	3.8	4.3	5.1	5.9
Renewables	1.6	1.6	1.6	1.9	2.2	2.6
Electricity	2.8	2.8	3.4	4.2	4.5	5.0
TRANSPORTATION	19.6	19.1	18.2	17.4	17.1	16.8
Liquids	19.0	18.5	17.5	16.6	16.2	15.8
Gases	0.6	0.6	0.6	0.7	0.7	0.8
Renewables (Alcohol)	--	--3/	0.1	0.1	0.2	0.2
FUEL SUBTOTALS						
Liquids	31.5	29.8	29.1	28.8	28.1	27.0
Gases	16.5	16.0	17.1	17.5	18.0	18.3
Coal Solids	3.4	3.3	4.0	4.5	5.3	6.1
Renewables	1.8	1.9	2.2	2.6	3.2	3.7
Electricity	7.1	7.2	8.3	9.8	10.9	12.3
TOTAL END-USE CONSUMPTION	60.4	58.2	60.7	63.2	65.5	67.4
CONVERSION LOSSES	17.3	17.4	20.1	23.8	26.5	29.7
TOTAL PRIMARY CONSUMPTION	77.7	75.7	80.6	87.0	91.9	97.0

1/ Residential/commercial and industrial based on 1973-78 trends, plus about 1.8 quads of biomass not included in most other DOE/EIA statistics. Transportation from Energy Information Administration, Monthly Energy Review.

2/ Totals may not add due to rounding. Liquids include products from shale oil and coal. Gases include synthetics from coal. Coal solids do not include coal consumed for synthetic liquid and gas production. Conversion includes losses in the production and distribution of electricity and production of coal synthetics.

3/ Less than 0.1 quad.

U.S. ENERGY CONVERSION AND PRODUCTION

- Table 1-3 summarizes energy conversion and production projections from 1980 to 2000 under midrange world oil price and economic growth assumptions. More details on conversion and production are provided in individual sections. (See Sections 5 through 9.)

- The units of Table 1-3 are quadrillion Btu's. Fuel specific units are provided in individual sections. Oil production measured in million barrels per day, for example, is provided in Section 5.

- Domestic energy production increases by about 23 quads between 1981 and 2000. Domestic oil and gas production declines by about 6 quads, while other fuels increase by about 29 quads by 2000.

- Of the 29 quad increase in non-oil and gas production to 2000, about 65 percent is coal, about 20 percent nuclear and about 15 percent hydro, geothermal and renewable fuels.

- In response to low world oil prices and the projected economic recovery, net oil imports increase from about 10.9 quads (5.1 MMBD) in 1981 to 12.3 quads (5.8 MMBD) by 1985. Net oil imports (excluding SPR) remain fairly constant from 1985 to 1990 and then decline, reaching about 9.8 quads (4.6 MMBD) by 2000. The decline in imports from 1990 to 2000 occurs despite a decline in U.S. oil production because of an even more rapid decline in U.S. oil consumption.

TABLE 1-3

U.S. ENERGY CONVERSION AND PRODUCTION
(Quadrillion Btu's Per Year)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
ELECTRICITY INPUTS						
Oil	2.6	2.2	2.3	1.8	1.3	1.0
Gas	3.8	3.7	2.9	2.9	2.4	2.0
Coal	12.1	12.7	14.6	17.6	20.4	23.5
Nuclear	2.7	2.9	4.9	7.3	8.3	9.2
Other	3.0	2.9	3.2	3.5	4.4	5.4
Subtotal	24.1	24.4	28.0	33.1	36.8	41.1
COAL FOR SYNTHETICS						
Coal Liquids	--	--	--	0.15	0.32	0.76
Coal Gas	--	--	--	0.15	0.32	0.53
Conversion Losses	--	--	--	0.20	0.36	1.01
Subtotal	--	--	--	0.5	1.0	2.3
DOMESTIC PRODUCTION						
Oil and NGL1/	20.5	20.4	19.3	17.8	17.1	16.0
Shale Oil	--	--	--	0.2	0.5	1.1
Natural Gas2/	20.1	20.1	18.7	18.4	17.8	17.5
Coal3/	19.2	18.7	21.7	25.8	31.4	37.0
Nuclear	2.7	2.9	4.9	7.3	8.3	9.2
Hydro/Geothermal	3.0	2.9	3.2	3.4	3.8	4.1
Renewables4/	1.8	1.9	2.2	2.7	3.9	5.0
Subtotal5/	67.3	66.8	70.0	75.6	82.9	90.0
NET IMPORTS						
Oil6/	13.4	10.9	12.3	12.7	11.3	9.8
Gas	1.0	0.8	1.2	1.8	2.1	2.2
Electricity	0.1	0.1	0.1	0.1	0.1	0.1
Coal (Exports)	(2.4)	(2.9)	(3.0)	(3.2)	(4.7)	(5.1)
Subtotal5/	12.2	9.0	10.6	11.5	8.9	7.0
STOCK DRAWDOWN (BUILD)	(1.8)	(0.1)	--	--	--	--
TOTAL CONSUMPTION5/	77.7	75.7	80.6	87.0	91.9	97.0
Net Oil Imports (MMBD)6/	(6.3)	(5.1)	(5.8)	(6.0)	(5.3)	(4.6)

1/ Excludes coal liquids and shale oil.
2/ Excludes synthetic gas from coal.
3/ Includes coal production for synthetics and exports.
4/ Renewables include about 1.8 quads of biomass not presently included in most other EIA/DOE statistics.
5/ Totals may not add due to rounding.
6/ Excludes Strategic Petroleum Reserve and U.S. territories net imports.

WORLD OIL PRICE SCENARIOS

- Table 1-4 shows the projected sensitivity of U.S. primary energy production and end-use consumption to changes in the world oil price. The low and high price cases are defined more completely in Section 2.

- As expected, given higher world oil prices, U.S. oil consumption declines and oil production increases--so that net oil imports decline considerably. In 1990, for example, U.S. net oil imports are 2.2 MMBD higher in the low compared to the high price scenario.

- The decline in electricity consumption under high oil prices results from an assumption that higher world oil prices reduce U.S. economic growth, which, in turn, reduces electricity demand. Since utilities are essentially already using as little oil and gas as is possible, lower electricity consumption tends to most heavily affect coal and nuclear consumption.

TABLE 1-4

WORLD OIL PRICE SCENARIOS[1]
(Quadrillion Btus per Year)

	PROJECTED							
	1985		1990		1995		2000	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
WORLD OIL PRICE[2] (1981 dollars/barrel)	27.50	37.00	31.50	57.00	41.00	71.00	51.00	74.00
DOMESTIC PRODUCTION								
Oil and NGL[3]	19.3	19.4	17.8	18.1	16.9	18.3	15.5	18.5
Non-Oil	49.9	51.4	57.1	58.7	62.6	66.4	68.1	75.3
Subtotal	69.2	70.8	74.9	76.8	79.5	84.7	83.6	93.8
NET IMPORTS								
Oil[4]	13.1	11.5	15.3	10.6	14.8	8.3	15.0	5.9
Net Non-Oil Imports (Exports)	(0.5)	(3.0)	0.3	(3.3)	0.3	(4.8)	0.1	(6.2)
Subtotal	12.6	8.5	15.6	7.3	15.1	3.5	15.1	(0.3)
CONSUMPTION BY FUEL								
Direct Oil	29.8	28.4	31.2	26.9	30.8	25.7	30.2	24.7
Direct Non-Oil	23.6	23.2	24.7	24.7	26.3	26.5	27.1	28.2
Electricity	8.3	8.1	10.0	9.4	10.9	10.6	12.3	12.2
End-Use Consumption	61.7	59.7	65.9	61.0	68.0	62.8	69.6	65.1
CONVERSION LOSSES	20.3	19.8	24.5	23.1	26.6	25.6	29.3	29.0
TOTAL CONSUMPTION	81.9	79.4	90.5	84.0	94.7	88.3	98.8	94.0
Net Oil Imports (MMBD)[3]	(6.2)	(5.5)	(7.2)	(5.0)	(7.0)	(3.9)	(7.1)	(2.8)

1/ Holding all other U.S. assumptions at midrange values, varies world oil prices as indicated. Economic growth varies slightly from midrange value due to the effect of higher or lower energy prices on GNP.

2/ U.S. refiner acquisition cost of crude oil imports.

3/ Includes shale oil, but excludes coal liquids.

4/ Excludes Strategic Petroleum Reserve and U.S. territories net imports.

U.S. ECONOMIC GROWTH SCENARIOS

- Table 1-5 shows how total U.S. energy production, imports and consumption by fuel are affected by changes in U.S. economic growth. Further information on the effect of changes in economic growth on end-use energy consumption and electricity production are provided in Section 4 on Energy Consumption and Section 9 on Electricity. (See pages 4-7 and 9-5.)
- Changes in economic growth have little impact on U.S. oil production which is more dependent on oil prices than on U.S. oil demand.
- Production of other fuels is strongly affected by economic growth since higher economic growth generates increased energy demand (and especially electricity demand) which in turn stimulates higher domestic energy production of non-oil fuels.
- Changes in economic growth directly affect net oil imports by influencing oil demand. Net oil imports increase by about 1.3 MMBD in 2000 when economic growth is increased by about 1 percent per year over the 1981 to 2000 time-frame.

TABLE 1-5

U.S. ECONOMIC GROWTH SCENARIOS[1]
(Quadrillion Btus per Year)

	PROJECTED							
	1985		1990		1995		2000	
	LOW	HIGH	LOW	HIGH	LOW	HIGH	LOW	HIGH
U.S. GNP GROWTH (%/year from 1981)	1.8	3.5	2.3	3.5	2.1	3.2	1.9	3.1
DOMESTIC PRODUCTION								
Oil and NGL	19.3	19.3	18.0	18.0	17.7	17.7	17.2	17.2
Natural Gas	18.2	19.0	18.0	18.8	17.8	19.2	16.4	20.0
Coal	20.7	22.8	23.7	27.5	29.8	34.9	31.9	42.0
Nuclear	4.6	5.2	6.6	7.9	7.9	9.3	7.9	10.1
Hydro/Geothermal	3.2	3.2	3.4	3.4	3.8	3.8	4.1	4.1
Renewables	2.2	2.2	2.6	2.7	3.7	4.3	4.3	6.5
Subtotal	68.2	71.6	72.3	78.3	80.7	89.2	81.8	100.0
NET IMPORTS								
Oil[2]	11.3	13.3	11.2	14.2	10.6	12.9	8.3	11.1
Gas	0.9	1.4	1.2	2.1	1.6	2.1	1.5	2.3
Electricity	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Coal (Exports)	(3.0)	(3.0)	(3.2)	(3.2)	(4.7)	(4.7)	(5.1)	(5.1)
Subtotal	9.4	11.8	9.3	13.2	7.7	10.5	4.8	8.4
CONSUMPTION BY FUEL								
Direct Oil	28.3	30.0	27.4	30.2	27.4	29.6	25.6	28.2
Direct Gas	16.6	17.4	16.7	17.9	17.5	19.2	16.5	21.0
Direct Coal	3.9	4.2	4.3	4.7	5.1	5.7	5.5	6.7
Direct Renewables	2.2	2.2	2.6	2.7	3.2	3.4	3.4	4.0
Electricity	7.8	8.7	8.9	10.4	10.3	12.2	10.3	14.2
End-Use Consumption	58.8	62.5	59.9	65.9	63.5	70.1	61.3	74.2
CONVERSION LOSSES	18.9	21.1	21.7	25.5	25.1	29.8	25.4	34.2
TOTAL CONSUMPTION	77.6	83.5	81.6	91.5	88.5	99.8	86.6	108.4
Net Oil Imports (MMBD)[2]	(5.4)	(6.3)	(5.2)	(6.7)	(5.0)	(6.1)	(3.9)	(5.2)

1/ Holding all other assumptions at midrange values, varies U.S. GNP as indicated.
2/ Excludes Strategic Petroleum Reserve and U.S. territories net imports.

FUEL PRICE SUMMARY BY SECTOR

o Table 1-6 provides projections of U.S. fuel prices by sector from 1980 to 2000. The prices are given in fuel specific units. Section 3 provides additional information on energy price projections measured in 1981 dollars per million Btu's. Also, Section 3 shows the effect on delivered prices of changes in world oil prices and other variables affecting prices.

TABLE 1-6

FUEL PRICE SUMMARY BY SECTOR
(1981 Dollars Per Physical Unit)[1]

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
WORLD OIL PRICE[2] (1981 $/barrel)	37[4]	37[4]	32.50	42.50	53.50	62.00
RESOURCE PRICES						
Refiner Crude Oil ($/bbl)	30.66[4]	35.64[4]	32.50	42.50	53.50	62.00
Wellhead Gas ($/Mcf)	1.74[4]	2.06[4]	3.80	5.44	6.62	7.45
Minemouth Coal ($/ton)	28.02	27.92	31.48	33.89	36.58	38.62
DELIVERED PRICES						
Residential Sector						
Distillate ($/gallon)	1.07[4]	1.21[4]	1.09	1.37	1.68	1.91
Liquid Gases ($/gallon)	0.63	0.71	0.65	0.82	1.00	1.13
Natural Gas ($/Mcf)	4.31[4]	4.56[4]	6.29	7.79	9.05	9.94
Electricity (¢/Kwh)	5.85[4]	6.20[4]	6.46	7.00	7.95	7.97
Commerical Sector						
Distillate ($/gallon)	0.96	1.09	1.00	1.26	1.55	1.77
Residual ($/barrel)	28.50[5]	32.50[5]	35.49	45.87	57.17	65.71
Liquid Gases ($/gallon)	0.51	0.69	0.63	0.81	0.99	1.14
Natural Gas ($/Mcf)	3.57	3.93	5.96	7.49	8.75	9.64
Electricity (¢/Kwh)	5.99[4]	6.29[4]	6.73	7.37	8.41	8.46
Industrial Sector						
Distillate ($/gallon)	0.94	1.07	0.98	1.23	1.51	1.73
Residual ($/barrel)	28.50[5]	32.50[5]	34.43	44.40	55.25	63.44
Liquid Gases ($/gallon)	0.61	0.69	0.63	0.81	0.99	1.14
Natural Gas ($/Mcf)	2.67	3.02	4.95	6.50	7.70	8.56
Coal ($/ton)	39.17	39.74	46.35	50.93	54.56	57.54
Electricity (¢/Kwh)	4.03[4]	4.29[4]	4.74	5.34	6.19	6.30
Transportation Sector						
Gasoline ($/gallon)	1.33[4]	1.35[4]	1.36	1.60	1.87	2.07
Distillate[3] ($/gallon)	0.95[4]	1.06[4]	1.10	1.40	1.72	1.96
Residual ($/barrel)	28.50[5]	32.50[5]	34.43	44.40	55.25	63.44
Jet Fuel[3] ($/gallon)	0.98[6]	1.05	0.98	1.28	1.60	1.85

---

[1] Thermal conversion factors: Liquid Petroleum Gas assumed to be 3.97 MMBtu's/Bbl; all other factors from the Energy Information Administration, *Monthly Energy Review*, May 1982. Except as noted, delivered prices are resource price plus estimated markups for processing and distribution.

[2] U.S. average refiner acquisition cost of imported crude oil.

[3] Excludes taxes.

[4] Energy Information Administration, *Monthly Energy Review*, May 1982.

[5] Data from the *Monthly Energy Review*, plus an estimate of taxes. The Monthly Energy Review does not give residual prices by sector.

[6] American Transport Association.

COMPARISON WITH NEPP U.S. ENERGY CONSUMPTION

Table 1-7 compares the July 1982 Energy Projections with the National Energy Policy Plan projections submitted to Congress in July 1981. One of the most important differences between the two sets of projections are the world oil price assumptions shown in Table 1-7. The July 1982 world oil price case is considerably lower than the NEPP case, especially during the early 1980's. Section 2 (page 2-4) provides some discussion on the reasons for the lower prices in the July 1982 projections. Another important difference in assumptions between the two projections is U.S. economic growth. Over the decade of the 1980's, the average rate of growth is about the same for the July 1982 projections as for NEPP (about 2.8 percent per year). The path of economic growth, however, is very different between the projections with the July 1982 projections growing slower in the early 1980's, but faster in the late 1980's, compared with NEPP.

Although total primary and end-use energy consumption is not very different between the two sets of projections, considerable differences do exist among the consumption of particular fuels--especially oil use:

- o Because of lower world oil prices and changed assumptions about industrial oil use, oil consumption by 2000 is 2.8 quads higher in the July 1982 projections compared with NEPP.

- o Oil consumption stays about the same in the residential/commercial sector and declines about 1.4 quads in the transportation sector. The decline in oil use in the transportation sector reflects recent data which shows a more rapid switch to automobiles with higher fuel efficiency than previously projected.

- o The biggest change in oil use occurs in the industrial sector where oil consumption is about 4.2 quads higher in the July 1982 projections compared to NEPP.

- o The increase in oil consumption in the industrial sector results primarily from lower world oil prices. Also, oil consumption for industrial feedstocks was assumed to remain constant in NEPP, but in the July 1982 projections is assumed to increase at a rate slightly lower than economic growth. Finally, oil consumption for small boilers and process heaters is assumed to decline slower from 1990 to 2000 compared to the assumption in NEPP. The slower decline results from a more conservative assessment of the ability to substitute natural gas, coal, electricity and renewables for oil in the industrial sector.

TABLE 1-7

COMPARISON WITH NEPP U.S. ENERGY CONSUMPTION[1/]
(Quadrillion Btus per Year)

	PROJECTED[2/]					
	1985		1990		2000	
	NEPP	JULY 1982	NEPP	JULY 1982	NEPP	JULY 1982
WORLD OIL PRICE (1981 $/barrel)	$44	$32.50	$52	$42.50	$70	$62
U.S. GNP GROWTH (%/year from 1980)	3.1%	2.5%	2.8%	2.8%	2.5%	2.5%
RESIDENTIAL/COMMERCIAL	18.0	16.8	18.4	17.4	18.9	19.2
Liquids	5.0	4.0	4.5	3.8	3.3	3.3
Gases	7.6	7.3	7.7	7.4	7.8	7.6
Coal Solids	0.2	0.2	0.3	0.2	0.3	0.2
Renewables	0.4	0.5	0.7	0.6	1.2	0.9
Electricity	4.8	4.8	5.2	5.5	6.3	7.2
INDUSTRIAL	25.4	25.6	27.1	28.2	30.4	31.4
Liquids	6.6	7.6	5.8	8.4	3.7	7.9
Gases	9.2	9.1	9.9	9.5	10.9	10.0
Coal Solids	4.5	3.8	5.2	4.3	7.2	5.9
Renewables	1.6	1.6	1.8	1.9	2.6	2.6
Electricity	3.5	3.4	4.4	4.2	6.0	5.0
TRANSPORTATION	18.2	18.2	17.6	17.4	18.4	16.8
Liquids	17.5	17.5	16.7	16.6	17.2	15.8
Gases	0.6	0.6	0.7	0.7	0.8	0.8
Renewables (Alcohol)	0.1	0.1	0.2	0.1	0.4	0.2
FUEL SUBTOTALS						
Liquids	29.1	29.1	27.0	28.8	24.2	27.0
Gases	17.4	17.1	18.3	17.5	19.5	18.3
Coal Solids	4.7	4.0	5.5	4.5	7.5	6.1
Renewables	2.1	2.2	2.7	2.6	4.2	3.7
Electricity	8.3	8.3	9.6	9.8	12.3	12.3
TOTAL END-USE CONSUMPTION	61.6	60.7	63.0	63.2	67.7	67.4
CONVERSION LOSSES	20.2	20.1	24.0	23.8	32.0	29.7
TOTAL PRIMARY CONSUMPTION	82.0	80.6	87.0	87.0	100.0	97.0

1/ Residential/commercial and industrial based on 1973-78 trends, plus about 1.8 quads of biomass not included in DOE/EIA statistics. Transportation from Energy Information Administration, Monthly Energy Review.

2/ Totals may not add due to rounding. Liquids include shale oil and synthetic liquids from coal. Gases include synthetics from coal. Coal solids do not include coal consumed for synthetic liquid and gas production.

COMPARISON WITH NEPP U.S. ENERGY CONVERSION AND PRODUCTION

In terms of domestic energy production shown in Table 1-8, the July 1982 projections have a lower year 2000 total production of 90.0 quads compared to a NEPP total of 100 quads. Of the 10.0 quad drop in year 2000 domestic production:

- 2.8 quads are from lower oil (including NGL and shale oil) production due to lower world oil prices in the 1982 to 1990 timeframe which results in about a 0.9 quad drop in enhanced oil recovery in 2000, a 0.7 quad drop in conventional production due to a lower level of exploration and development in the 1980's and a 1.2 quad drop in oil shale production.
- Natural gas production is about equal to the NEPP estimate.
- Much of the 10.0 quad decrease in domestic production results from a lower projected production of coal, down about 5.0 quads compared to NEPP in 2000. The drop in coal production results mainly from lower coal demand for synthetic oil and natural gas production (down about 4.1 quads for coal synthetics in Table 1-8).
- Increased oil consumption in the industrial sector (see Table 1-7) coupled with a lower oil production causes net oil imports in the July 1982 projections to increase to 4.6 MMBD by 2000 compared to a NEPP projection of only 1.2 MMBD.

TABLE 1-8

COMPARISON WITH NEPP U.S. ENERGY CONVERSION AND PRODUCTION[1]
(Quadrillion Btus per Year)

	PROJECTED					
	1985		1990		2000	
	NEPP	JULY 1982	NEPP	JULY 1982	NEPP	JULY 1982
ENERGY CONVERSION						
ELECTRICITY INPUTS						
Oil	2.4	2.3	1.8	1.8	1.1	1.0
Gas	2.8	2.9	2.9	2.9	2.2	2.0
Coal	14.3	14.6	16.7	17.6	22.0	23.5
Nuclear	5.5	4.9	7.6	7.3	10.6	9.2
Other	3.3	3.2	3.6	3.5	5.3	5.4
Subtotal	28.3	28.0	32.5	33.1	41.2	41.1
COAL FOR SYNTHETICS	0.15	--	1.3	0.5	6.4	2.3
DOMESTIC PRODUCTION[2]						
Oil and NGL	18.2	19.3	17.9	17.8	17.7	16.0
Shale Oil	0.1	--	0.5	0.2	2.3	1.1
Natural Gas	18.0	18.7	18.5	18.4	18.0	17.5
Coal	22.0	21.7	27.0	25.8	42.0	37.0
Nuclear	5.5	4.9	7.6	7.3	10.6	9.2
Hydro/Geothermal[3]	3.2	3.2	3.4	3.4	4.1	4.1
Renewables	2.2	2.2	2.8	2.7	5.4	5.0
Subtotal	69.0	70.0	78.0	75.6	100.0	90.0
NET IMPORTS						
Oil[4]	13.0	12.3	10.0	12.7	3.0	9.8
Gas	2.0	1.2	2.0	1.8	2.0	2.2
Electricity	0.1	0.1	0.1	0.1	0.1	0.1
Coal (Exports)	(2.7)	(3.0)	(3.5)	(3.2)	(5.9)	(5.1)
Subtotal	12.5	10.6	8.5	11.5	0.0	7.0
TOTAL CONSUMPTION[5]	82.0	80.6	87.0	87.0	100.0	97.0
Net Oil Imports (MMBD)[4]	(6.3)	(5.8)	(4.8)	(6.0)	(1.2)	(4.6)

---

[1] Forecast taken from the National Energy Policy Plan (NEPP), completed July 1981.

[2] See Table 1-3, page 1-5 for production footnotes.

[3] Hydro/geothermal as reported in NEPP included 0.2 quads of electricity imports shown separately in the net electricity imports category here.

[4] Excludes Strategic Petroleum Reserve and U.S. territories net imports.

[5] Totals may not add due to rounding.

SECTION 2: WORLD OIL PRICES

The world energy market analysis presented in this section establishes low, high and midrange world oil market scenarios which attempt to reasonably reflect uncertainty, from a U.S. vantage point, primarily regarding the world oil price and secondarily regarding free-world oil and total energy consumption.

The price paths depict long-term economic pressure for world oil price change. Although it is perhaps better to use such smooth paths for policy analysis, the actual price path will probably consist of a series of sharp increases followed by periods of price stability or decline such as occurred in the 1970's.

Since the objective is to develop cases which, by reflecting the uncertainty faced by U.S. markets, can be used in the analysis of domestic issues, world oil prices are defined as the average acquisition cost to U.S. refiners of crude oil imports. Thus, the prices given include insurance and transportation costs required to deliver crude oil to domestic refiners (referred to as cost, insurance and freight or C.I.F.).

The differences between scenarios reflect uncertainties in underlying factors controlling world oil supply and demand--such as feedback from oil prices and economic growth, oil and non-oil energy production and net imports or exports by Centrally Planned Economies (CPE). As illustrated in Figures 2-3, 2-4 and 2-5, the world oil price is much more volatile than either free-world oil consumption or primary energy consumption.

SUMMARY OF WORLD OIL PRICE SCENARIOS

- Each dramatic change in the world oil price sets in motion a wave of behavioral alterations. Although most of the impact is felt in the first few years, the effects resulting from long-term decisions, such as equipment purchases, may have an effect on energy markets for decades.

- Following five years of slow decline, the 1979/1980 doubling of world oil prices in real terms stimulated a reduction in oil consumption. The demand response was soon sufficient to exert downward pressure on the crude price, which in the midrange scenario, is projected to fall to around $31.00 per barrel, in 1981 dollars, by 1983.

- Economic recovery and several years of real decline in the world oil price are expected to produce behavior resulting in higher oil consumption. Through 1985 the tendency to increase consumption will be moderated by previous efforts in the opposite direction. Both oil consumption and price are projected to slowly increase with price reaching $32.50 per barrel in 1985.

- Low oil prices and the economic recovery, in part stimulated by low prices, are projected to cause increasingly rapid growth in oil consumption in the mid to late 1980's. With the installation of equipment ordered under slack market/low price expectation conditions and the resumption of some wasteful consumption behavior, demand exceeds the level which can comfortably be supplied and prices begin to rapidly escalate reaching $42.50 per barrel by 1990.

- Three years of very rapid price increases in the late 1980's once again set a conservation pattern in motion. With increased production from marginal sources compensating for a slight loss of OPEC capacity, oil consumption and the rate of increase in prices decline through 1985.

- The energy markets are projected to stabilize in the 1995 to 2000 period with small increases in consumption causing moderate (less than 3 percent per year) real growth in crude prices, which reach $62.00 in 2000.

- The low and high world oil price scenarios exhibit behavior similar to the midrange. Differences in timing and magnitude reflect, respectively, optimistic and pessimistic assumptions about energy supply availability, the impact of energy prices on the economy and coal penetration potential (see Table 2-3 and comments).

TABLE 2-1

SUMMARY OF WORLD OIL PRICE SCENARIOS[1]
(1981 Dollars Per Barrel)

			PROJECTED			
	1980[2]	1981	1985	1990	1995	2000
LOW PRICES	$37.00	$37.00	$27.50	$31.50	$41.00	$51.00
MIDRANGE PRICES	37.00	37.00	32.50	42.50	53.50	62.00
HIGH PRICES	37.00	37.00	37.00	57.00	71.00	74.00

	SHORT-TERM YEARLY PRICES (1981 Dollars/Barrel)		
YEAR	LOW PRICES	MIDRANGE PRICES	HIGH PRICES
1981	37.00	37.00	37.00
1982	32.20	33.80	34.60
1983	28.00	30.90	34.20
1984	27.60	31.60	35.40
1985	27.50	32.50	37.00

---

[1] U.S. average refiner acquisition cost of crude oil imports.

[2] Adjusted to equal 1981 dollars. The 1980 price in 1980 dollars averaged $34 per barrel.

COMPARISON WITH NEPP WORLD OIL PRICE SCENARIOS

General

- o The major changes between the NEPP cases and the July 1982 scenarios are in short-term market expectations. While NEPP assumed a stabilized market with gradual 2 to 3 percent real increases in the world oil price, the revised scenarios assume a slack near-term market causing a price slide which then creates a tight market and a price run up prior to the emergence of a stabilized market in the mid to late 1990's.

- o Some of the reasons for this change in expectations are outlined below.

Saudi Arabian Oil Production Policies

- o In the spring of 1981 many analysts assumed that Saudi Arabia would be willing to reduce oil production to sustain a 2 or 3 percent real increase in world oil prices consistent with the announced long-term OPEC pricing strategy.

- o Instead Saudi Arabia increased production apparently to bring OPEC price hawks into line and to stabilize the OPEC benchmark price below the 1980 level. While it was assumed Saudi Arabia might be willing to produce as little as 6.5 MMBD in late 1981 and early 1982, they actually produced at close to their maximum (over 10 MMBD).

Low World Oil Consumption

- o Oil demand has been lower in 1981 and 1982 than projected for NEPP. This lower oil demand has contributed to the near-term world oil glut thus applying downward pressure on prices. Some of the reasons for lower oil consumption include low economic growth, appreciation of the dollar and, as a result of the 1979/1980 world oil price increases, more fuel switching and conservation than projected.

Inventory Behavior

- o For NEPP, neutral world oil inventory behavior was assumed. In fact, oil inventories were drawndown heavily in late 1981 and early 1982. These reductions in oil inventories occurred in spite of the uncertainties associated with the Iran/Iraq war.

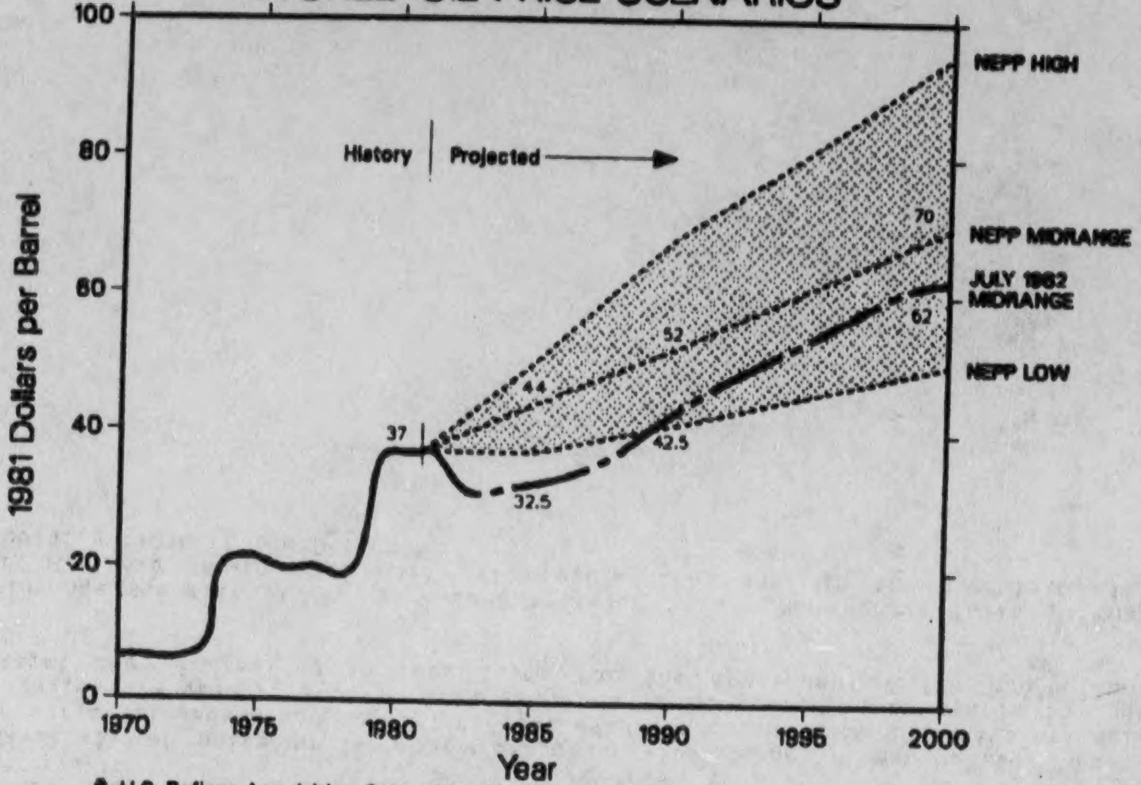
- o Reasons for this inventory behavior include:

  - -- Lower oil consumption;
  - -- An excess of OPEC production capacity;
  - -- High interest rates;
  - — Reduced price expectations.

- o The change from neutral oil inventory behavior (as assumed in NEPP) to a stock drawdown can have a strong impact on near-term prices. The only way to reduce inventories is to encourage the outflow by reducing product prices and to reduce the inflow by not buying crude oil. Both measures result in pressures to reduce prices.

Figure 2-1

COMPARISON WITH NEPP WORLD OIL PRICE SCENARIOS *



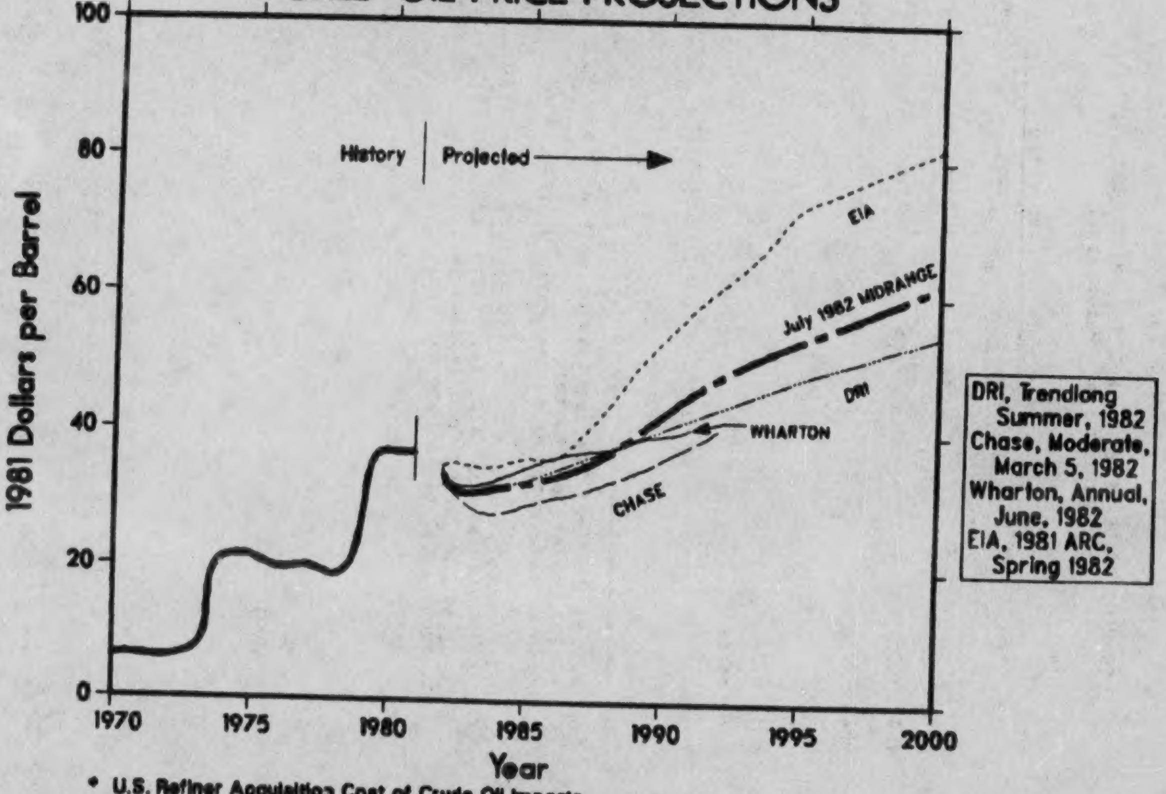
* U.S. Refiner Acquisition Cost of Crude Oil Imports.

COMPARISON WITH OTHER RECENT PROJECTIONS

- The diversity of price projections reflect a wide range of assumptions about future world oil demand and supply, as well as different methods of analysis. All those reviewed, however, show world oil prices to be declining or stable in the near-term, then increasing in real terms for the remainder of the projection period.
- The midrange scenario of the July 1982 revision of the NEPP cases falls in the middle of these recent world oil price projections and, in the near-term, is particularly close to the DRI path.

Figure 2-2

COMPARISON OF RECENT WORLD OIL PRICE PROJECTIONS *



* U.S. Refiner Acquisition Cost of Crude Oil Imports.

TABLE 2-2

COMPARISON OF RECENT WORLD OIL PRICE PROJECTIONS[1]
(1981 Dollars Per Barrel)

	PROJECTED		
	1985	1990	2000
CHASE[2]	28.67	36.49	NA
WHARTON[3]	32.66	37.64	NA
DRI[4]	32.70	40.51	54.49
EIA[5]	36.04	53.52	81.91
July 1982			
Midrange	32.50	42.50	62.00
Range	27.50-37.00	31.50-57.00	51.00-74.00

---

[1] Average U.S. refiner acquisition cost of crude oil imports in 1981 dollars per barrel.

[2] Chase Econometrics, Moderate, March 5, 1982.

[3] Wharton, Annual, June 1982.

[4] DRI Forecast, TRENDLONG, Energy Review, Summer 1982.

[5] Energy Information Administration, 1981 Annual Report to Congress, converted from 1980 dollars. to equal 1.092 times 1980 dollars.

KEY ASSUMPTIONS

General

- In defining scenarios, a large number of factors which can affect the output must be considered.
- Based on a review of information from the DOE Office of International Affairs, the Energy Information Administration, the Central Intelligence Agency, subscription forecasting services such as DRI and energy industry forecasts, a set of midrange assumptions and "extreme" ranges for key factors was established.
- Some points regarding the main assumptions, a few of which are detailed on Table 2-3, are highlighted below.

Economic Growth Rates

- Since uncertainty facing the U.S. is being analyzed, U.S. economic growth potential is kept at the midrange value in all scenarios.
- The achieved economic growth rate is the potential modified by the effect of changing energy prices (see Table 2-4 for the achieved growth rates). To account for uncertainty regarding the strength of this feedback, the midrange value was tested over a range of ±22.5 percent.
- The short-term assumptions range from a sluggish recovery from the recession beginning in late 1983/early 1984, to a strong recovery beginning later this year or early next year.
- After 1985, the range extends from 0.63 percent per year less growth in GDP than the midrange case to 0.63 percent per year more growth.

Non-U.S./Non-OPEC Oil and Gas Production

- Uncertainty regarding desired non-U.S./non-OPEC oil and gas production rates is assumed to increase from ±2.5 percent in 1982 to ±6.3 percent in 1985 and ±10 percent in 2000.

Coal Supply, Demand and Exports

- Uncertainty regarding the ability to quickly provide additional coal supplies was represented by altering the time it takes to convert investment dollars into usable non-U.S. production capacity by ±0.75 years.
- There is a great deal of uncertainty regarding the speed at which non-coal consumers will switch to coal and thus coal's market penetration potential. This was accounted for by varying the average replacement period for non-U.S. equipment by ±5 years.
- The major constraint on U.S. coal exports is port loading capacity which is assumed to increase to no more than 270 million tons per year by 2000.

Non-U.S. Nuclear and Renewables

- Uncertainty regarding non-U.S. nuclear and renewables supply is assumed to increase to ±6.3 percent in 1985 and ±12.5 percent by 2000.

TABLE 2-3

KEY ASSUMPTIONS

A. ECONOMIC GROWTH RATE POTENTIAL ASSUMING CONSTANT ENERGY PRICES (Percent Change Per Year)

	1980-1985		1985-1990		1990-2000		1980-2000	
	MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE
U.S.	3.0	NA	3.5	NA	2.5	NA	2.9	NA
Other OECD	2.6	2.1-3.2	3.1	2.5-2.7	2.5	1.8-3.1	2.7	2.1-3.3
OECD Subtotal	2.8	2.5-3.1	3.3	2.9-3.7	2.5	2.1-2.9	2.8	2.4-3.1
OPEC	4.2	3.6-5.0	5.3	4.7-5.9	5.2	4.6-5.9	5.0	4.4-5.7
Rest of the Free World	4.1	3.5-4.8	4.8	4.1-5.4	3.6	2.9-4.2	4.0	3.4-4.6
TOTAL FREE WORLD	3.0	2.7-3.4	3.6	3.1-4.0	2.8	2.3-3.2	3.0	2.6-3.5

NA: Not applicable (midrange U.S. economic growth assumed in all scenarios).

NOTE: For achieved economic growth rates with projected increasing energy prices, see Tables 1-1 and 2-4.

B. NET CPE OIL EXPORTS[1] (MMBD)

	1980	1985		1990		1995		2000	
		MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RAN
Oil	1.0	0.1	(0.6)-0.6	(1.0)	(2.3)-0.9	(1.0)	(2.3)-0.9	(1.0)	(2.3)-(
Gas	0.4	0.5	0.4-1.0	1.0	0.4-1.6	1.5	0.9-2.1	2.0	1.4-
Coal	0.3	0.6	0.2-1.0	0.7	0.2-1.2	0.9	0.3-1.4	1.1	0.5-

---

[1] Parentheses indicate negative numbers.

KEY ASSUMPTIONS (continued)

OPEC Behavior

- It is assumed that the moderates gained control of OPEC during the last year and will continue to maintain considerable influence, especially in the near-term.

- It is further assumed that the Saudis and other moderates want to increase the world oil price in real terms at the slow and steady pace (perhaps 2 to 3 percent in most years) which will cause production to remain at levels which they find reasonable. This would stabilize demand, allowing producers to maintain high revenues and continue producing reasonable quantities of crude into the next century.

Sensitivity To Key Assumptions

- Although changes in an individual variable can have a substantial impact on price, changes within the ranges tested have very small impacts on oil consumption and on primary energy consumption. Feebacks in the marketplace cause any resulting change in consumption to be directly translated into a higher or lower price which in turn reduces the magnitude of the response. For example, without changing OPEC capacity or any other assumptions high economic growth causes higher demand, which causes higher prices, which holds down demand.

- Changes in the economic growth rate cause the price, oil consumption and total energy consumption to move in the direction of the change in economic. The range tested had its most significant impact on price (over 12 percent in 1990).

- Changes in the oil supply variables (OPEC capacity, non-OPEC oil production and net CPE imports) cause oil consumption and primary energy consumption to move in the direction of the change, but cause the world oil price to move in the opposite direction. Of these, OPEC capacity had the most significant impact within the ranges tested.

- Changes in non-oil supply variables cause primary energy consumption to move in the direction of the change, but cause oil demand and, therefore, the world oil price to move in the opposite direction.

TABLE 2-3 (continued)

KEY ASSUMPTIONS

C. MAXIMUM SUSTAINABLE OPEC PRODUCTION CAPACITY[1/] (MMBD)

	ACTUAL[2/]	PROJECTED[3/]					
	1980	1985		1990		2000	
		MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE
Algeria	1.1	0.8	0.7-0.8	0.7	0.6-0.8	0.6	0.5-0.7
Ecuador	0.2	0.2	0.1-0.2	0.1	0.1-0.2	0.1	0.1-0.1
Gabon	0.2	0.2	0.1-0.2	0.1	0.1-0.2	0.1	(S)-0.1
Indonesia	1.6	1.5	1.4-1.7	1.4	1.3-1.6	1.1	1.0-1.4
Iran	5.5	3.0	2.7-3.4	3.5	2.7-3.5	3.5	2.6-3.5
Iraq	3.5	3.8	3.7-4.0	4.0	3.7-4.0	4.0	3.6-4.0
Kuwait	2.5	2.0	2.0-2.0	2.0	2.0-2.0	2.0	2.0-2.0
Libya	2.2	1.8	1.6-1.9	1.5	1.3-1.8	1.5	1.0-2.0
Neutral Zone	0.6	0.6	0.5-0.6	0.5	0.5-0.6	0.5	0.4-0.5
Nigeria	2.2	2.0	1.9-2.2	1.8	1.7-1.9	1.6	1.4-1.8
Qatar	0.6	0.5	0.4-0.5	0.4	0.4-0.5	0.4	0.3-0.4
Saudi Arabia	9.5	10.5	10.1-10.9	11.0	10.4-11.8	10.9	10.4-11.8
UAE	2.4	2.2	2.0-2.4	2.2	2.0-2.4	2.2	2.0-2.4
Venezuela	2.4	2.0	2.0-2.2	2.0	1.9-2.1	2.0	1.9-2.5
Subtotal	34.5	31.1	29.2-33.1	31.2	28.9-33.4	30.2	27.3-33.2
Natural Gas Liquids	0.9	1.4	1.2-1.6	1.8	1.5-2.1	2.0	1.8-2.4
TOTAL CAPACITY	35.4	32.5	30.4-34.7	33.0	30.5-35.5	32.2	29.2-35.6

[1/] Maximum sustainable OPEC capacity, generally 90-95 percent of installed capacity, represents the maximum production rate which can be sustained for several months. Actual production will usually be 80 to 85 percent of capacity. Totals may not add due to rounding.

[2/] EIA, National Foreign Assessment Center, International Energy Statistical Review, February 24, 1981.

[3/] Based on information supplied by the Office of Market Analysis, International Affairs, DOE, August 26, 1981.

(S) Less than 0.05 million barrels per day.

WORLD OIL PRICE SCENARIOS

General

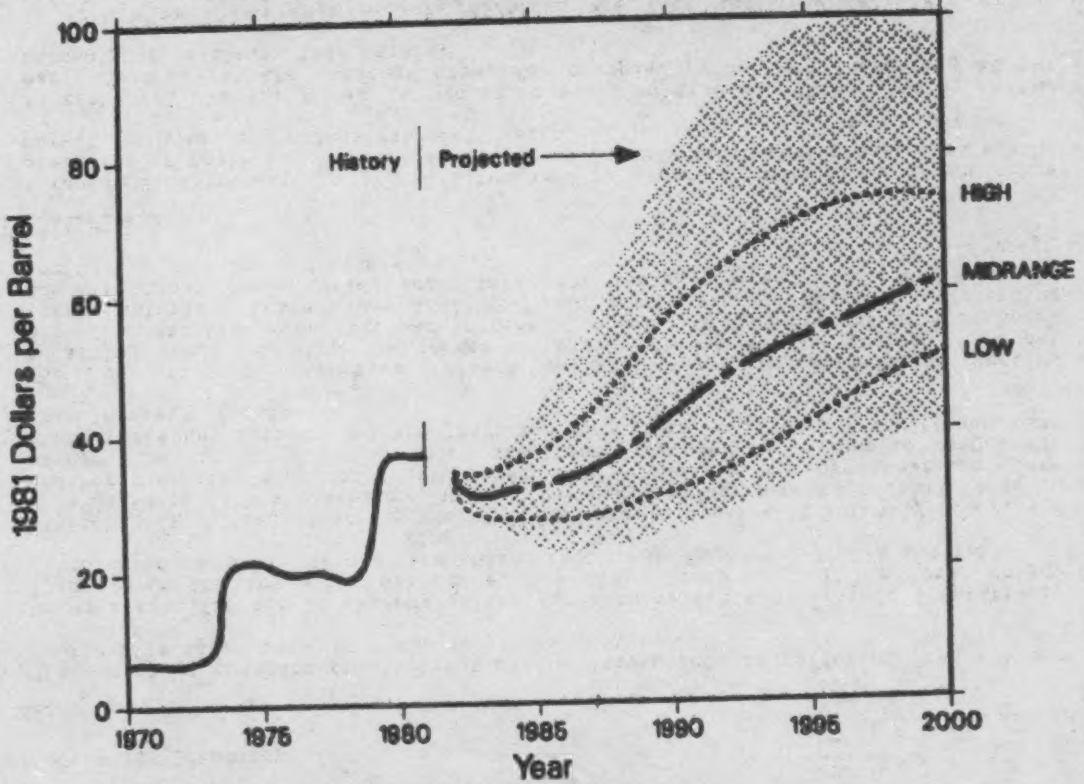
- The impact of changing combinations of the assumptions is different from the sum of the effects of changing these variables individually.
- Using a specific set of extreme values for each variable presented, a relatively large range for the world oil price, for oil consumption, or for total energy consumption can be developed (see shaded regions on Figures 2-3, 2-4 and 2-5).
- It is highly unlikely that any one of these extreme cases will actually occur, and a large range in one dimension (say oil consumption) may produce a small range in another dimension (say world oil price). Two scenarios have been developed (see dashed lines on the figures) which simultaneously produce reasonable ranges for these three key outputs and are therefore more useful for policy-making purposes than the extreme cases.
- The low and high scenarios reflect optimistic and pessimistic assumptions regarding energy supply, the impact of energy prices on the economy and coal market penetration potential and in general account for 80 percent of the uncertainty intervals tested (see Table 2-3 and comments). Uncertainties regarding economic growth were tested separately (see Tables 2-4 and 2-11) and were not included in the low and high scenarios.

World Oil Prices

- A rapid price increase in 1973 was followed by a period of relative slight price stability or decline. A second price run up in 1979 could not be sustained by the market, however, and prices soon fell rapidly.
- In each case a price run-up is projected starting around 1987 and ending in the early 1990's. In the midrange case, for example, prices are increasing at 5-7 percent per year over this period.
- It should be noted that market feedbacks are such that low near-term prices stimulate demand and increase the rate of price growth in later years and, as expected, high near-term prices have the opposite effect.

Figure 2-3

WORLD OIL PRICE SCENARIOS*



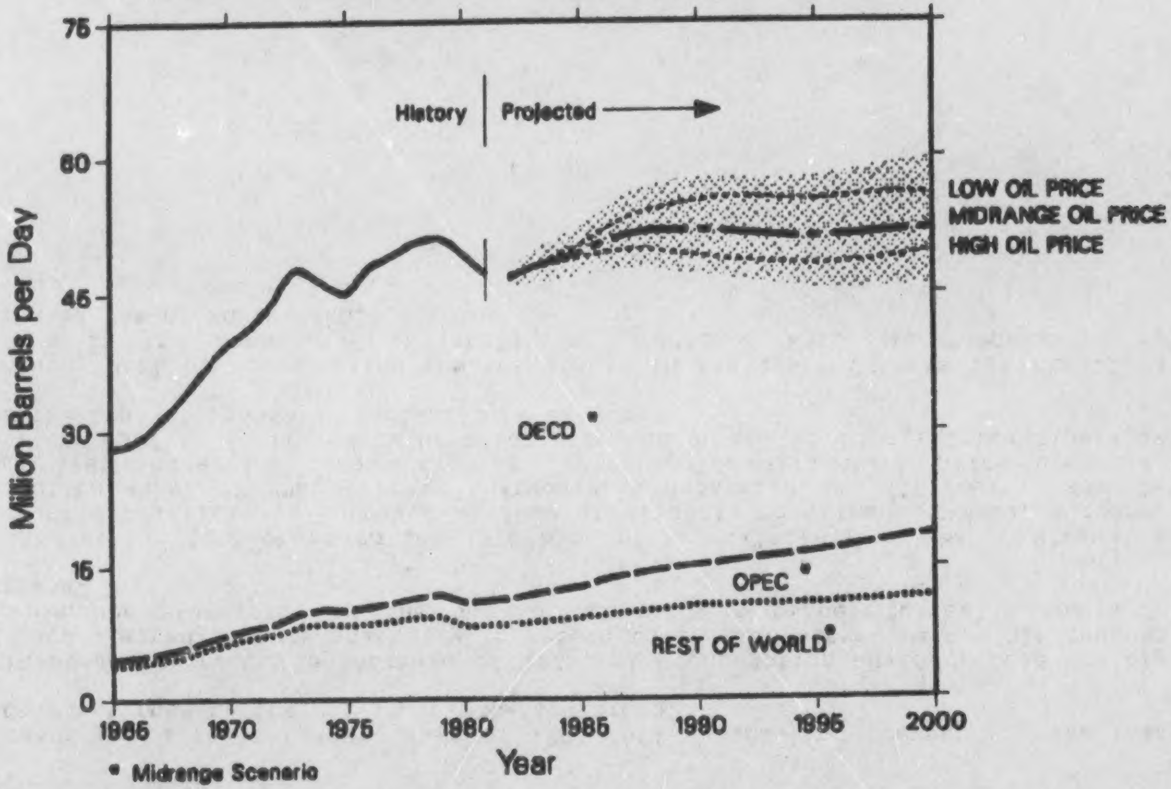
* U.S. Refiner Acquisition Cost of Crude Oil Imports

FREE-WORLD OIL CONSUMPTION

- In response to the price increase of 1973, oil consumption dropped sharply then quickly returned to the previous long-term trend.
- In response to the price increase of 1979, oil consumption again dropped sharply and is projected to once again try to return to the long-term trend. This rebound may even be exagerated by the substantial drop in prices following the 1979 increase.
- By 1988 demand is back up to the 1979 high of approximately 52 MMBD. Given the free-world's ability to supply a maximum of slightly more than 55 MMBD, marginal production above 52 MMBD becomes increasingly expensive and difficult. Shortly after 1985 increasing demand creates increasingly significant price pressure. Thus, the 1987 to early 1990's behavior observed on the world oil price figure is just the type of response that would be expected.
- Although total oil consumption remains stable in the 1990's, there is actually a decline in the demand of industrialized countries which is compensated by increased demand in developing regions.

Figure 2-4

FREE WORLD OIL CONSUMPTION

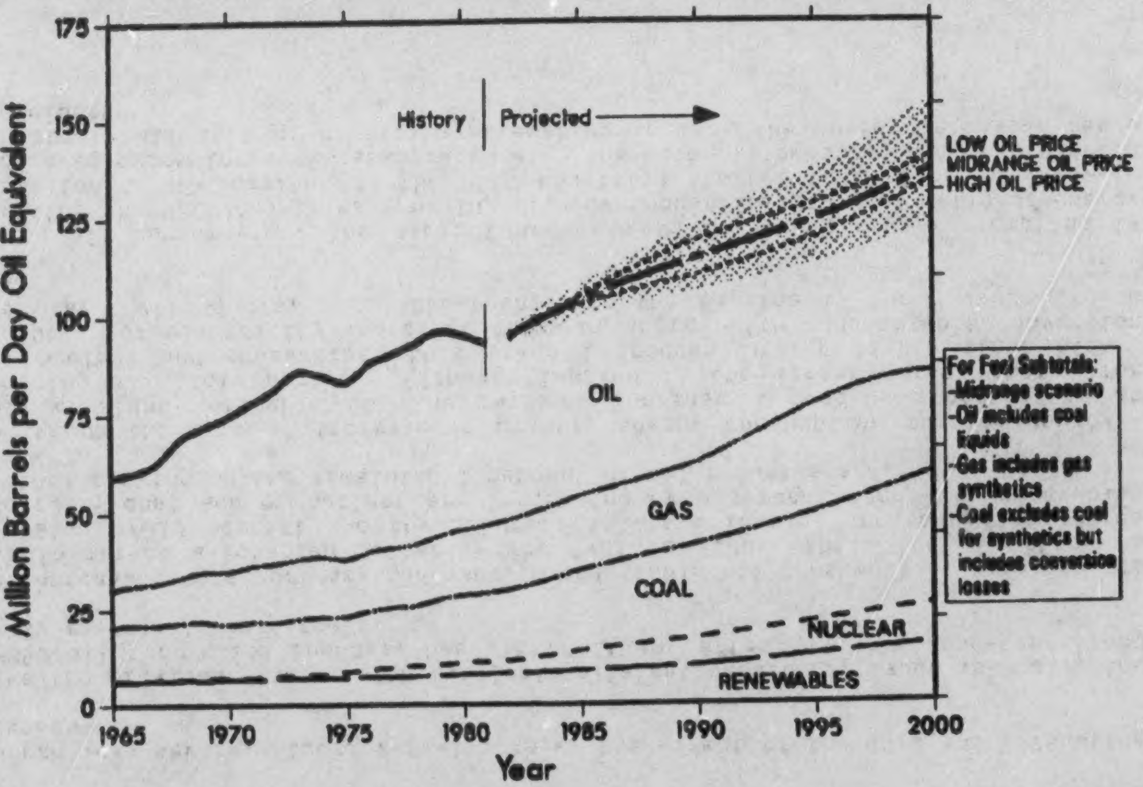


FREE-WORLD PRIMARY ENERGY CONSUMPTION

- Although less severe, Figure 2-5 also shows the effect of the 1973 and 1979 price increases.
- Unlike the previous figure, with available alternatives to oil (such as coal), the 52 MMBD oil production boundary has little if any effect and the long-term trend quickly re-establishes itself.
- With increasing total primary consumption and stable oil consumption, major shifts occur in market allocation patterns from 1981 to 2000. While the oil share is decreasing by 13 percent and the natural gas share remains constant; the shares captured by coal and by nuclear are increasing by 5 percent each with renewables and other picking up the remaining 3 percent of oil's lost share.
- Even though the rate of increase in primary energy consumption remains approximately constant through 2000, the rate of increase in end-use consumption is decreasing over this period. Although implied in the larger market shares for coal, nuclear and renewables, this trend is hidden in the figure since higher consumption of electricity and other forms of energy with considerable conversion losses (synthetic fuels, etc.) counterbalance the decline in the end-use growth rate.
- As with oil consumption, the rate of increase in primary energy consumption is lowest for the OECD countries. Having already industrialized, the ratio of energy consumption to GDP growth for the OECD countries started to decline in 1973--in response to price increases associated with the Arab oil embargo--and is projected to be about half that of countries attempting to meet the energy intensive needs of development.

Figure 2-5

FREE WORLD PRIMARY ENERGY CONSUMPTION



SUMMARY OF THE EFFECT OF ECONOMIC GROWTH ASSUMPTIONS

- By the year 2000, changing only the economic growth assumptions has almost the same effect as changing all of the assumptions used to develop the low and high scenarios. However, the price paths resulting from changes in the economic assumptions follow the midrange path in a much less exagerated fashion and with a much smaller range in the near-term then do the low and high scenario paths.

- The higher non-U.S. economic growth assumptions do cause non-U.S. consumption of oil and other fuels to increase. This causes higher prices which slow both U.S. achieved economic growth and consumption. The net effect, however, is higher free-world oil and total energy demand, even with higher world oil prices. The opposite is true for lower economic growth assumptions (see Table 2-11 for regional details).

- Feedbacks in the marketplace are projected to limit the impact of changing the economic growth assumptions. High growth stimulates increased consumption, but also higher energy prices which hold down consumption. Therefore, the range in oil consumption and free-world oil consumption generated by changing this assumption is relatively small.

TABLE 2-4

SUMMARY OF THE EFFECT OF ECONOMIC GROWTH ASSUMPTIONS1/

			PROJECTED			
	1980	1981	1985	1990	1990	2000
WORLD OIL PRICE2/ (1981 dollars/barrel)						
Low GDP	37.00	37.00	31.50	38.00	46.50	53.00
Midrange GDP	37.00	37.00	32.50	42.50	53.50	62.00
High GDP	37.00	37.00	33.50	48.50	63.00	73.50
FREE-WORLD OIL3/ CONSUMPTION (MMBD)						
Low GDP	49.7	47.4	48.7	51.3	50.4	50.3
Midrange GDP	49.7	47.4	49.5	51.8	50.9	51.7
High GDP	49.7	47.4	50.2	52.1	51.6	52.8
FREE-WORLD TOTAL ENERGY CONSUMPTION (MMBD oil-equivalent)						
Low GDP	94.6	93.4	103.1	113.4	121.7	131.6
Midrange GDP	94.6	93.4	104.0	114.8	124.5	137.3
High GDP	94.6	93.4	105.1	116.0	127.7	143.3

1/ See Table 2-3 for economic growth rate assumptions.

2/ U.S. average refiner acquisition cost of crude oil imports.

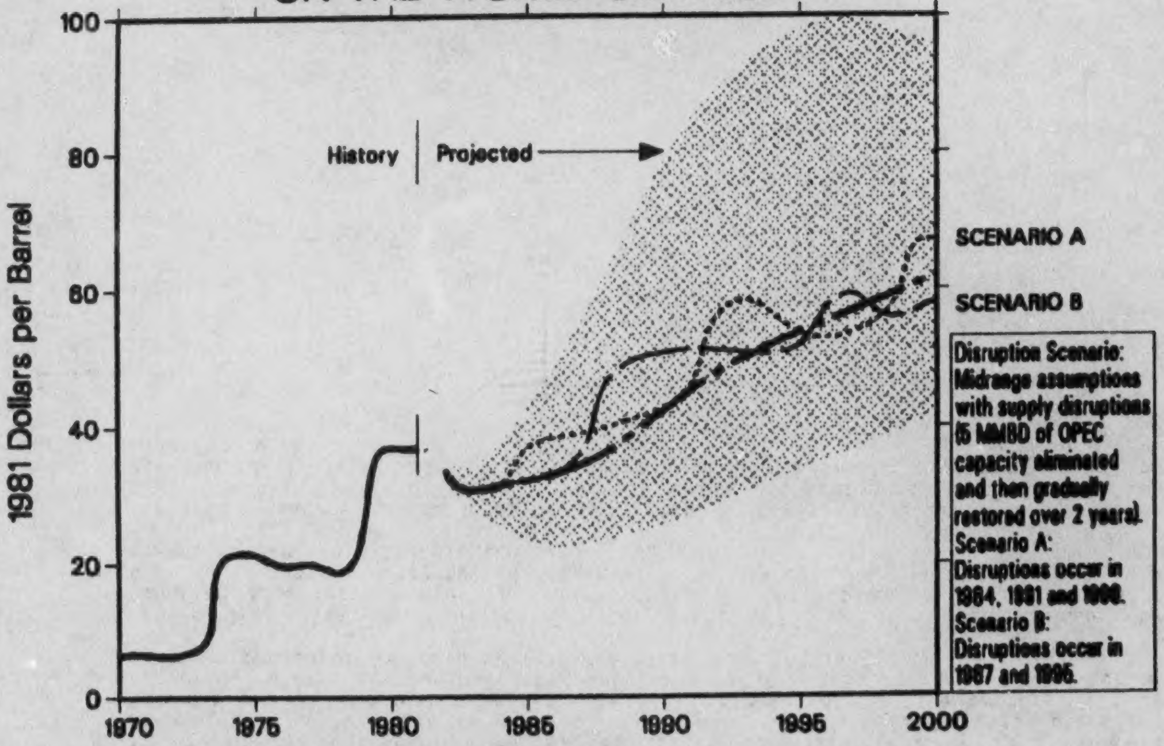
3/ Includes coal liquids, heavy oil, tar sands, enhanced oil recovery, shale oil, natural gas liquids and liquids from biomass.

EFFECT OF DISRUPTIONS ON THE WORLD OIL PRICE

- As previously mentioned, the July 1982 price scenarios represent the economic pressure for world oil price changes. It is not believed that the world oil price will in fact follow such a smooth path for the remainder of the century. It is expected, rather, that as occurred over the past 10 years, there will be a series of sharp increases followed by relative price stability.
- Figure 2-6 shows two examples of such paths. These cases were produced by creating a series of abrupt 5 MMBD OPEC capacity reductions which are gradually eliminated over a 2 year period. Even with the disruptions, the general long-term trends remain approximately the same.
- Scenario A assumes disruptions in 1984, 1991 and 1998 while Scenario B assumes disruptions in 1987 and 1995. The actual number and timing of such price run ups are unpredictable, it is therefore better to use a smooth long-term trend for planning purposes.

Figure 2-6

EFFECT OF DISRUPTIONS ON THE WORLD OIL PRICE *



* U.S. Refiner Acquisition Cost of Crude Oil Imports.

DETAILED TABLES

- Tables 2-5 through 2-11 provide the detailed numbers used in the analysis and in developing the preceeding figures.

TABLE 2-5

FREE-WORLD ENERGY CONSUMPTION AND ECONOMIC GROWTH RATES
(Percent Per Year Real)

		PROJECTED			
	1960-1980	1980-1985 MIDRANGE	1985-1990 MIDRANGE	1990-2000 MIDRANGE	1980-2000 MIDRANGE
PRIMARY ENERGY CONSUMPTION					
U.S.		0.6	1.4	1.1	1.1
Other OECD		1.8	1.2	1.3	1.4
OECD Subtotal	3.9	1.2	1.3	1.2	1.2
OPEC	6.9	6.3	5.9	5.4	5.7
Rest of the Free World	5.8	4.2	3.6	2.8	3.4
TOTAL FREE WORLD	4.2	1.9	2.0	1.8	1.9
ACHIEVED ECONOMIC GROWTH[1]					
U.S.		2.5	3.1	2.1	2.4
Other OECD		2.7	2.9	2.2	2.5
OECD Subtotal	4.1	2.6	3.0	2.2	2.5
OPEC	5.8	5.9	5.4	5.2	5.4
Rest of the Free World	5.4	4.3	4.3	3.3	3.8
TOTAL FREE WORLD	4.7	2.9	3.3	2.5	2.8

---

[1] For assumed potential economic growth rates given constant real prices, see Table 2-3.

TABLE 2-6

FREE-WORLD OIL CONSUMPTION AND SUPPLY[1]
(Millions Barrels Per Day)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
LIQUIDS CONSUMPTION (Includes Coal Liquids)						
U.S.[2]	17.1	16.0	15.7	15.2	14.4	13.7
Other OECD	21.4	20.0	20.9	21.2	19.8	19.7
OECD Subtotal[3]	38.5	36.0	36.6	36.4	34.2	33.4
OPEC	2.9	3.0	3.5	4.6	5.8	7.1
Rest of the Free World	8.3	8.4	9.4	10.6	10.8	11.3
TOTAL OIL CONSUMPTION	49.7	47.4	49.5	51.8	50.9	51.7
OIL PRODUCTION[4] (Excludes Coal Liquids)						
U.S.[2]	10.8	10.9	9.9	9.2	9.0	8.6
Other OECD	4.8	4.8	5.2	5.5	5.8	6.1
OECD Subtotal[4]	15.6	15.7	15.1	14.7	14.8	14.8
OPEC	28.0	23.8	26.1	28.6	26.6	26.1
Rest of the Free World	5.7	6.3	8.4	9.4	10.2	11.1
COAL LIQUIDS	--	--	0.1	0.1	0.3	0.7
Subtotal Liquids Production	49.3	45.4	49.6	52.8	51.9	52.7
STOCK DRAWDOWN	(0.6)	0.7	(0.2)	--	--	--
CPE NET OIL EXPORTS[5]	1.0	1.0	0.1	(1.0)	(1.0)	(1.0)
TOTAL LIQUIDS SUPPLY	49.7	47.4	49.5	51.8	50.9	51.7

---

[1] Totals may not add due to rounding. Parentheses indicate negative numbers.
[2] Includes about 0.5 MMBD of refinery gain.
[3] Includes U.S. territories.
[4] Includes natural gas liquids, shale oil, heavy oil, tar sands, enhanced oil recovery, and liquids from biomass.
[5] CPE--Centrally Planned Economies.

TABLE 2-7

FREE-WORLD ENERGY SUPPLY[1]
(Million Barrels Per Day Oil Equivalent)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
OIL[2] (Excludes Coal Liquids)	50.3	46.9	49.4	51.8	50.5	51.0
U.S.[3]	10.8	10.9	9.9	9.2	9.0	8.6
Other OECD	4.8	4.8	5.2	5.5	5.7	6.1
OECD Subtotal	15.6	15.7	15.1	14.7	14.7	14.7
OPEC	28.0	23.8	26.1	28.6	26.6	26.1
Rest of the Free World	5.7	6.3	8.4	9.5	10.5	11.1
CPE Net Oil Exports[4]	1.0	1.0	0.1	(1.0)	(1.0)	(1.0)
COAL[5]	17.4	18.1	21.3	24.7	29.7	35.3
U.S.	8.5	9.0	10.3	12.2	14.9	17.7
Other OECD	6.1	6.2	7.6	8.2	9.1	10.2
OECD Subtotal	14.6	15.2	17.9	20.4	23.9	27.9
OPEC	--	--	--	--	--	--
Rest of the Free World	2.5	2.5	2.9	3.7	4.8	6.3
CPE Net Coal Exports[4]	0.3	0.4	0.6	0.7	0.9	1.1
GAS (Excludes Synthetics)	16.7	17.2	18.9	20.7	22.4	25.1
U.S.	9.1	9.0	8.8	8.7	8.4	8.3
Other OECD	4.9	5.0	5.3	5.5	5.6	5.8
OECD Subtotal	14.0	14.0	14.1	14.2	14.0	14.1
OPEC	1.2	1.3	1.9	2.5	3.3	4.8
Rest of the Free World	1.1	1.5	2.4	3.1	3.6	4.2
CPE Net Gas Exports[4]	0.4	0.4	0.5	1.0	1.5	2.0
NUCLEAR	3.0	3.1	5.2	7.4	8.9	10.5
U.S.	1.3	1.4	2.3	3.4	3.9	4.3
Other OECD	1.6	1.7	2.7	3.6	4.3	5.2
OECD Subtotal	2.9	3.1	5.0	7.1	8.2	9.5
OPEC	--	--	--	--	--	0.1
Rest of the Free World	0.1	0.1	0.2	0.4	0.6	0.9
RENEWABLES/OTHER	7.8	8.0	9.0	10.3	13.0	15.5
U.S.	2.3	2.3	2.6	2.9	3.6	4.3
Other OECD	3.9	4.0	4.3	4.6	5.4	6.5
OECD Subtotal	6.2	6.3	6.9	7.5	9.0	10.8
OPEC	0.1	0.2	0.2	0.2	0.2	0.2
Rest of the Free World	1.5	1.5	2.0	2.6	3.8	4.2
TOTAL PRIMARY PRODUCTION	95.2	93.3	104.0	114.8	124.5	137.3
U.S.	32.0	32.6	33.9	36.2	39.8	43.3
Other OECD	21.3	21.8	25.2	27.2	30.2	33.8
OECD Subtotal	53.3	54.4	59.0	63.5	69.9	77.0
OPEC	29.3	25.2	28.1	31.1	30.2	31.2
Rest of the Free World	10.9	11.9	15.9	19.3	22.9	26.9
CPE Net Exports[4]	1.7	1.8	1.2	0.8	1.5	2.2

---

[1] Totals may not add due to rounding and the inclusion of stock changes. Parentheses indicate negative numbers.

[2] Includes heavy oil, tar sands, enhanced oil recovery, shale oil, natural gas liquids, and liquids from biomass. Units are physical barrels.

[3] Includes about 0.5 MMBD of refinery gain.

[4] CPE--Centrally Planned Economies.

[5] Includes coal production for synthetics and coal used to produce liquids and gaseous fuels.

TABLE 2-8

FREE-WORLD ENERGY CONSUMPTION[1]
(Million Barrels Per Day Oil Equivalent)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
LIQUIDS[2] (Includes Coal Liquids)	49.7	47.4	49.5	51.8	50.9	51.7
U.S.	17.1	16.0	15.7	15.2	14.4	13.7
Other OECD	21.4	20.0	20.9	21.2	19.8	19.7
OECD Subtotal	38.5	36.0	36.6	36.5	34.1	33.4
OPEC	2.9	3.0	3.5	4.6	5.8	7.1
Rest of the Free World	8.3	8.4	9.4	10.6	10.8	11.3
COAL[3] (Excludes Synthetic Feedstocks)	17.4	18.0	21.2	24.4	28.8	33.4
U.S.	7.3	7.6	8.8	10.4	12.1	14.0
Other OECD	7.5	7.8	9.3	10.1	11.8	13.2
OECD Subtotal	14.8	15.4	18.1	20.6	23.9	27.2
OPEC	--	--	--	--	--	--
Rest of the Free World	2.6	2.7	3.1	3.8	4.9	6.3
COAL SYNTHETICS CONVERSION LOSS	--	--	--	0.1	0.3	0.7
GAS (Includes Synthetics)	16.8	17.3	18.9	20.8	22.6	25.4
U.S.	9.6	9.4	9.4	9.6	9.6	9.6
Other OECD	5.4	5.7	6.2	6.7	7.3	7.9
OECD Subtotal	15.0	15.1	15.6	16.3	16.9	17.5
OPEC	0.8	1.0	1.5	2.1	3.1	4.6
Rest of the Free World	1.0	1.2	1.8	2.3	2.7	3.3
NUCLEAR	3.0	3.1	5.2	7.4	8.9	10.5
U.S.	1.3	1.4	2.3	3.4	3.9	4.3
Other OECD	1.6	1.7	2.7	3.6	4.3	5.2
OECD Subtotal	2.9	3.0	5.0	7.0	8.2	9.5
OPEC	--	--	--	--	--	0.1
Rest of the Free World	0.1	0.1	0.2	0.4	0.6	0.9
RENEWABLES/OTHER	7.8	8.0	9.0	10.3	13.0	15.5
U.S.	2.3	2.3	2.6	2.9	3.6	4.3
Other OECD	3.9	4.0	4.3	4.6	5.4	6.5
OECD Subtotal	6.2	6.3	6.9	7.5	9.0	10.8
OPEC	0.1	0.1	0.2	0.2	0.2	0.2
Rest of the Free World	1.5	1.5	2.0	2.6	3.8	4.4
TOTAL PRIMARY CONSUMPTION	94.6	93.4	104.0	114.8	124.5	137.3
U.S.	37.6	36.7	38.7	41.6	43.8	46.5
Other OECD	39.8	39.2	43.5	46.6	48.6	52.7
OECD Subtotal	77.4	75.8	82.2	88.1	92.4	99.2
OPEC	3.8	4.1	5.2	7.0	9.2	12.0
Rest of the Free World	13.4	13.9	16.5	19.8	22.8	26.2

---

[1] Totals may not add due to rounding.

[2] Also, includes heavy oil, tar sands, enhanced oil recovery, shale oil, natural gas liquids, and liquids from biomass. Units are physical barrels.

[3] Also, excludes coal used to produce liquids and gaseous fuels.

TABLE 2-9

FREE-WORLD ENERGY TRADE[1]
(Million Barrels Per Day Oil Equivalent)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
NET OIL EXPORTS						
U.S.	(6.3)	(5.1)	(5.8)	(6.0)	(5.3)	(4.6)
Other OECD	(16.6)	(15.2)	(15.8)	(15.7)	(14.0)	(13.5)
OECD Subtotal	(22.9)	(20.4)	(21.6)	(21.7)	(19.3)	(18.1)
OPEC	25.1	20.8	22.5	23.9	20.8	19.1
Rest of the Free World	(2.5)	(2.0)	(0.9)	(1.2)	(0.5)	0.1
CPE Net Oil Exports[2]	1.0	1.0	0.1	(1.0)	(1.0)	(1.0)
NET COAL EXPORTS						
U.S.	1.2	1.4	1.4	1.5	2.2	2.4
Other OECD	(1.4)	(1.6)	(1.7)	(2.0)	(2.7)	(3.2)
OECD Subtotal	(0.2)	(0.2)	(0.3)	(0.5)	(0.5)	(0.8)
OPEC	--	--	--	--	--	--
Rest of the Free World	(0.2)	(0.3)	(0.3)	(0.2)	(0.3)	(0.3)
CPE Net Coal Exports[2]	0.3	0.4	0.6	0.7	0.9	1.1
NET GAS EXPORTS						
U.S.	(0.5)	(0.4)	(0.6)	(0.9)	(1.0)	(1.0)
Other OECD	(0.5)	(0.7)	(0.9)	(1.3)	(1.7)	(2.1)
OECD Subtotal	(1.0)	(1.0)	(1.5)	(2.2)	(2.7)	(3.1)
OPEC	0.4	0.3	0.4	0.3	0.2	0.2
Rest of the Free World	0.2	0.3	0.6	0.8	1.0	0.9
CPE Net Gas Exports[2]	0.4	0.4	0.5	1.0	1.5	2.0
TOTAL NET ENERGY EXPORTS						
U.S.	(5.6)	(4.2)	(5.0)	(5.4)	(4.1)	(3.1)
Other OECD	(18.5)	(17.3)	(18.4)	(19.0)	(18.4)	(18.8)
OECD Subtotal	(24.1)	(21.7)	(23.3)	(24.4)	(22.5)	(22.0)
OPEC	25.5	21.2	22.9	24.2	20.9	19.2
Rest of the Free World	(2.5)	(2.1)	(0.7)	(0.6)	0.2	0.7
CPE Net Exports[2]	1.7	1.8	1.2	0.8	1.5	2.2

---

[1] Totals may not add due to rounding. Parentheses indicate net imports.
[2] CPE--Centrally Planned Economies.

TABLE 2-10

FREE-WORLD ENERGY BALANCE BY WORLD OIL PRICE SCENARIO[1]
(Million Barrels Per Day Oil Equivalent)

	PROJECTED					
	1985		1990		2000	
	LOW WOP	HIGH WOP	LOW WOP	HIGH WOP	LOW WOP	HIGH WOP
FREE-WORLD ENERGY SUPPLY[2]						
OIL[3] (Excludes Coal Liquids)	50.5	49.3	55.0	49.1	54.7	48.4
U.S.[4]	9.9	10.0	9.1	9.4	7.4	9.5
Other OECD	5.4	5.0	5.7	5.6	5.9	6.8
OECD Subtotal	15.3	15.0	14.8	15.0	13.3	16.3
OPEC	26.0	26.5	29.8	26.9	29.3	23.1
Rest of the Free World	8.9	8.1	9.9	9.1	11.5	10.8
CPE Net Oil Exports[5]	0.5	(0.4)	0.5	(2.0)	0.3	(2.0)
NON-OIL[3]	55.0	54.0	64.2	61.9	84.9	86.0
U.S.	23.5	24.3	26.8	27.6	32.2	35.6
Other OECD	20.4	19.4	22.4	20.9	28.3	27.5
OECD Subtotal	43.9	43.7	49.2	48.5	60.5	63.1
OPEC	1.6	2.3	2.4	3.3	4.8	5.5
Rest of the Free World	7.6	7.3	10.0	9.3	15.5	15.3
CPE Net Non-Oil Exports[5]	1.8	0.7	2.7	0.9	4.2	2.2
TOTAL PRIMARY PRODUCTION	105.5	103.3	119.1	111.0	139.5	134.3
U.S.	33.4	34.3	35.9	37.0	39.6	45.1
Other OECD	25.8	24.4	28.1	26.5	34.2	34.3
OECD Subtotal	59.2	58.7	64.0	63.5	73.8	79.4
OPEC	27.6	28.8	32.2	30.2	34.1	28.6
Rest of the Free World	16.5	15.4	19.9	18.4	27.0	26.1
CPE Net Exports[5]	2.3	0.3	3.2	(1.1)	4.7	0.2
FREE-WORLD ENERGY CONSUMPTION						
LIQUIDS (Includes Coal Liquids)	50.5	49.3	55.1	49.3	55.1	49.4
U.S.	16.1	15.7	16.4	14.7	14.7	12.7
Other OECD	21.6	20.4	23.3	19.5	21.8	18.1
OECD Subtotal	37.7	36.1	39.7	34.2	36.5	30.8
OPEC	3.6	3.6	4.5	4.7	6.9	7.2
Rest of the Free World	9.3	9.6	10.8	10.6	11.7	11.4
NON-LIQUIDS	55.0	54.0	64.0	61.7	84.4	84.9
U.S.	23.5	22.9	26.8	26.0	32.1	32.5
Other OECD	22.7	22.2	25.6	24.1	32.7	32.6
OECD Subtotal	46.2	45.1	52.4	50.1	64.8	65.1
OPEC	1.6	1.7	2.4	2.4	4.9	4.8
Rest of the Free World	7.1	7.3	9.3	9.1	14.6	15.1
TOTAL PRIMARY CONSUMPTION	105.5	103.3	119.1	111.0	139.5	134.3
U.S.	39.6	38.6	43.2	40.7	46.8	45.2
Other OECD	44.3	42.6	48.9	43.6	54.5	50.7
OECD Subtotal	83.9	81.2	92.1	84.3	101.3	95.9
OPEC	5.2	5.3	6.9	7.1	11.8	12.0
Rest of the Free World	16.4	16.9	20.1	19.7	26.3	26.5

---

[1] Totals may not add due to rounding. Parentheses indicate negative numbers.

[2] Includes stock changes.

[3] Includes heavy oil, tar sands, enhanced oil recovery, shale oil, natural gas liquids, and liquids from biomass. Units are physical barrels.

[4] Includes about 0.5 MMBD of refinery gain.

[5] CPE--Centrally Planned Economies.

TABLE 2-11

FREE-WORLD ENERGY BALANCE BY ECONOMIC GROWTH SCENARIO1/
(Million Barrels Per Day Oil Equivalent)

	PROJECTED					
	1985		1990		2000	
	LOW GDP	HIGH GDP	LOW GDP	HIGH GDP	LOW GDP	HIGH GDP
FREE-WORLD ENERGY SUPPLY2/						
OIL3/ (Excludes Coal Liquids)	48.6	50.2	51.2	52.0	49.6	51.9
U.S.4/	9.9	9.9	9.2	9.2	8.0	9.1
Other OECD	5.2	5.2	5.5	5.5	5.8	6.3
OECD Subtotal	15.1	15.1	14.7	14.7	13.8	15.4
OPEC	25.4	26.7	28.1	28.7	25.9	26.1
Rest of the Free World	8.4	8.4	9.5	9.5	11.0	11.4
CPE Net Oil Exports5/	0.1	0.1	(1.0)	(1.0)	(1.0)	(1.0)
NON-OIL3/	54.3	54.8	62.2	64.1	82.0	91.3
U.S.	24.0	23.9	26.9	27.2	34.0	35.7
Other OECD	19.9	20.0	21.4	22.2	26.1	29.8
OECD Subtotal	43.9	43.9	48.3	49.4	60.1	65.5
OPEC	1.9	2.2	2.4	3.0	4.4	5.8
Rest of the Free World	7.3	7.6	9.6	10.0	14.3	16.8
CPE Net Non-Oil Exports5/	1.1	1.1	1.8	1.8	3.2	3.2
TOTAL PRIMARY PRODUCTION	103.1	105.1	113.4	116.0	131.6	143.3
U.S.	33.9	33.8	36.1	36.4	42.0	44.8
Other OECD	25.1	25.2	26.9	27.7	31.9	36.1
OECD Subtotal	59.0	59.0	63.0	64.1	73.9	80.9
OPEC	27.3	28.9	30.5	31.7	30.3	31.9
Rest of the Free World	15.7	16.0	19.1	19.5	25.3	28.2
CPE Net Exports5/	1.2	1.2	0.8	0.8	2.2	2.2
FREE-WORLD ENERGY CONSUMPTION						
LIQUIDS (Includes Coal Liquids)	48.7	50.2	51.3	52.1	50.3	52.8
U.S.	15.6	15.7	15.5	14.8	14.1	12.9
Other OECD	20.6	21.1	21.1	21.1	19.3	19.7
OECD Subtotal	36.2	36.8	36.6	35.9	33.4	32.6
OPEC	3.4	3.7	4.4	5.0	6.4	7.9
Rest of the Free World	9.0	9.8	10.2	11.2	10.5	12.4
NON-LIQUIDS	54.4	54.9	62.1	63.9	81.3	90.5
U.S.	23.3	23.1	26.6	26.2	32.8	32.6
Other OECD	22.4	22.8	24.5	25.7	30.6	35.8
OECD Subtotal	45.7	45.9	51.1	51.9	63.4	68.4
OPEC	1.7	1.7	2.2	2.5	4.4	5.5
Rest of the Free World	7.1	7.2	8.9	11.8	13.4	16.6
TOTAL PRIMARY CONSUMPTION	103.1	105.1	113.4	116.0	131.6	143.3
U.S.	38.9	38.8	42.1	41.0	46.9	45.5
Other OECD	43.0	43.9	45.6	46.8	49.9	55.5
OECD Subtotal	81.9	82.7	87.7	87.8	96.8	101.0
OPEC	5.1	5.4	6.6	7.5	10.8	13.4
Rest of the Free World	16.1	17.0	19.1	20.7	23.9	29.0

1/ Totals may not add due to rounding. Parentheses indicate negative numbers.
2/ Includes stock changes.
3/ Includes heavy oil, tar sands, enhanced oil recovery, shale oil, natural gas liquids, and liquids from biomass. Units are physical barrels.
4/ Includes about 0.5 MMBD of refinery gain.
5/ CPE--Centrally Planned Economies.

SECTION 3: DOMESTIC ENERGY PRICES

National average energy price projections (both for resources and for delivered energy forms) have been developed in conjunction with this analysis. This section first looks at how and why fuel prices are projected to change over time under the midrange scenario. Then, a series of tables shows the effects of deviating from the midrange assumptions.

FUEL PRICE SUMMARY BY SECTOR

Short-Term Fuel Prices

- Table 3-1 shows U.S. fuel prices in 1981 dollars per million Btu's. Table 1-6, on page 1-13, shows the same price projections reported in fuel specific units (e.g., gasoline in cents per gallon).
- Price trends of the recent past and projections of the near future, reflect a temporary excess of energy supply resulting from reduced demand. This demand reduction is a response to the rapid energy price increases of the last few years caused by events such as:
  - The 1979 world oil price jump;
  - The January 1981 decontrol of domestic oil;
  - Progress in the phased decontrol of natural gas under the Natural Gas Policy Act of 1978 (NGPA); and
  - The gradual decontrol of coal transport rates under the Stagger's Rail Act of 1980.
- Excess oil supply has caused a near-term real decline in petroleum prices and a temporary slow down in the real rate of increase in other fuel prices. These trends are projected to continue until sometime in 1983 (see Section 2).

Long-Term Fuel Prices

- Petroleum product prices are projected to generally mirror world oil price behavior (see Section 2).
- Depending on the tightness of the market, natural gas prices, after the NGPA runs its course in 1985, are expected to increase at a slightly slower pace than oil.
- In the late 1980's and early 1990's, electricity prices are projected to increase primarily as a result of a rapid increase in demand due to strong economic growth and higher capital costs from investment in new generating capacity as the high cost of oil and gas drive utilities to other fuel sources.
- Coal will not be greatly affected by the price increase of other fuels. It is considered to be so abundant that demand can easily be met. Therefore, prices are projected to remain stable, growing at less than 2 percent per year.
- The markups (defined as the difference between the resource price and delivered price of a fuel) which are added to resource prices to estimate delivered prices are based on historical relationships. There is no guarantee, however, that these relationships will hold indefinitely. In fact, recent evidence suggests that structural changes may have occurred in the transportation distillate (diesel) and residual fuel markets. Such changes could cause out year diesel fuel prices to be higher and residual fuel prices to be lower than projected in Table 3-1.

TABLE 5-1

FUEL PRICE SUMMARY BY SECTOR
(1981 Dollars Per Million Btu's)[1]

MAKE CHANGE
to this page
in yellow Book

	1980	1981	PROJECTED 1985 MIDRANGE	 1990 MIDRANGE	 1995 MIDRANGE	 2000 MIDRANGE
WORLD OIL PRICE[2] (1981 $/barrel)	37.0[4]	37.0[4]	32.50	42.50	53.50	62.00
RESOURCE PRICES						
Refiner Crude Oil	5.29[4]	6.14[4]	5.58	7.34	9.25	10.69
Wellhead Gas	1.71[4]	2.01[4]	4.05	5.67	6.95	7.68
Minemouth Coal	1.19	1.19	1.34	1.44	1.57	1.66
DELIVERED PRICES						
Residential Sector						
Distillate	7.70[4]	8.69[4]	7.89	9.92	12.13	13.81
Liquid Gases	6.64	7.50	6.93	8.69	10.59	12.03
Natural Gas	4.21[4]	4.46[4]	6.53	7.99	9.38	10.17
Electricity	17.16[4]	18.17[4]	18.73	20.26	23.10	23.32
Commercial Sector						
Distillate	6.89	7.83	7.21	9.13	11.21	12.78
Residual	4.53[5]	5.17[5]	5.64	7.29	9.09	10.45
Liquid Gases	6.46	7.35	6.76	8.58	10.57	12.06
Natural Gas	3.49	3.84	6.20	7.70	9.08	9.87
Electricity	17.54[4]	18.43[4]	19.51	21.33	24.44	24.76
Industrial Sector						
Distillate	6.77	7.68	7.08	8.93	10.95	12.47
Residual	4.53[5]	5.17[5]	5.47	7.06	8.78	10.09
Liquid Gases	6.46	7.35	6.76	8.58	10.57	12.06
Natural Gas	2.61	2.95	5.20	6.73	8.05	8.81
Coal	1.54	1.57	1.83	2.01	2.17	2.29
Electricity	11.81[4]	12.57[4]	13.75	15.47	18.00	18.44
Transportation Sector						
Gasoline	10.66[4]	10.82[4]	10.91	12.85	14.96	16.56
Distillate[3]	6.87[4]	7.66[4]	7.99	10.10	12.40	14.14
Residual	4.53[5]	5.17[5]	5.47	7.06	8.78	10.09
Jet Fuel[3]	7.25[6]	7.81	7.29	9.50	11.90	13.72

1/ Except as noted, delivered prices are resource price plus estimated markups for processing and distribution.

2/ U.S. average refiner acquisition cost of imported crude oil.

3/ Excludes taxes.

4/ Energy Information Administration, Monthly Energy Review, May 1982.

5/ Data from the Monthly Energy Review, plus an estimate of taxes. The Monthly Energy Review does not give residual prices by sector.

6/ American Transport Association.

CONSUMER FUEL PRICES

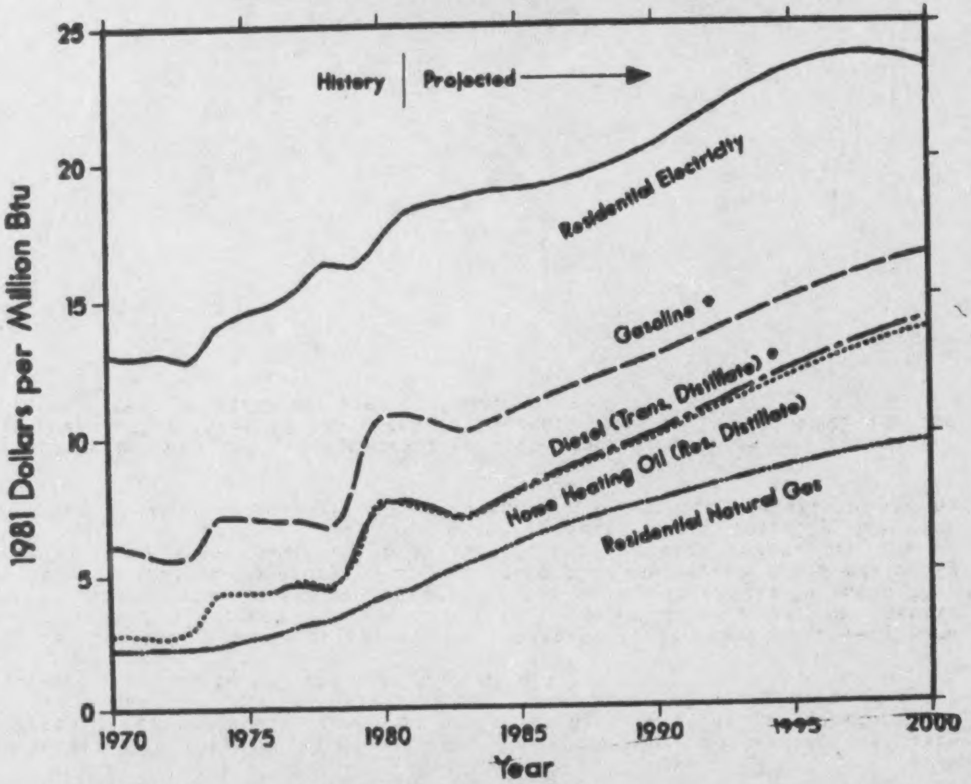
- The gap between the residential natural gas price and the home heating oil price is projected to be narrowest from 1983 until immediately after gas controls are lifted. Once gas has been allowed to reach its market clearing price, yearly increases are expected to be less than that of oil.

- Although residential electricity prices are projected to increase at a very slow rate (less than 1.5 percent per year from 1981 to 2000) on a per Btu basis, electricity remains the highest priced residential fuel. It should be noted that this basis of comparison measures the heat content of delivered fuels excluding end-use efficiency losses which, though significant for most fuels, are low or negligible for electricity. Since these energy sources are actually used for diverse purposes at widely different efficiencies, a per Btu comparison may be misleading.

- The difference between the average gasoline price including taxes and the diesel fuel price excluding taxes is projected to decrease from $3.16 per MMBtu (or 29¢ per gallon) in 1981 to $2.42 (or 11¢) in 2000.

Figure 3-1

CONSUMER FUEL PRICES



* Gasoline Includes Taxes, Diesel Excludes Taxes

INDUSTRIAL FUEL PRICES

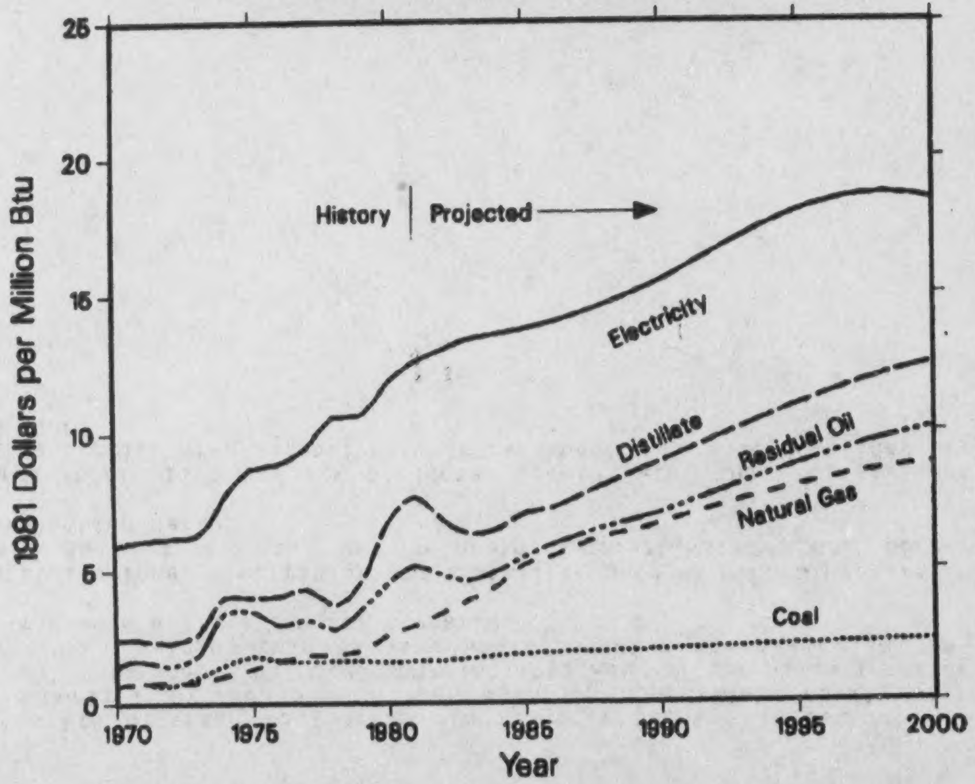
- Natural gas prices are expected to increase to slightly below the residual oil price following decontrol in 1985 and to then maintain approximate parity with this substitute fuel. It should be noted that the 1985 natural gas price increase resulting from the NGPA pricing rule is very small assuming the lower (in comparison to NEPP) midrange world oil price scenario.

- Due to higher initial prices, electricity and distillate grow at much slower rates than residual oil and natural gas, yet maintain substantially higher prices throughout the projection period.

- Given coal's low initial price and low projected growth rate, the wedge between the price of coal and price of alternative fuels is expected to widen considerably between 1980 and 2000.

Figure 3-2

INDUSTRIAL FUEL PRICES



COMPARISON OF 1990 FUEL PRICE PROJECTIONS

- The July 1982 resource and delivered price projections fall between the EIA and DRI projections--as expected given that this world oil price scenario is also bounded by these alternative estimates.

- Except for coal, the markups used in converting July 1982 projected resource prices into delivered prices is less than that implied in both alternatives.

TABLE 3-2

COMPARISON OF 1990 FUEL PRICE PROJECTIONS
(1981 Dollars Per Million Btu's)

	PROJECTED			
	EIA[1]	DRI[2]	NEPP[3]	JULY 1982[4]
WORLD OIL PRICE[5] (1981 $/barrel)	53.52	40.51	52.0	42.5
RESOURCE PRICES				
Refiner Crude Oil	9.18	6.85	8.97	7.34
Wellhead Gas	6.54	NA	6.61	5.31
Minemouth Coal	1.53	NA	1.48	1.46
DELIVERED PRICES				
Residential Sector				
Distillate	11.62	7.79[6]	11.81	9.92
Liquid Gases	10.10	NA	10.32	8.69
Natural Gas	8.07	6.62	8.80	7.60
Electricity	19.22	22.65	19.90	20.53
Commercial Sector				
Distillate	11.24	7.79[6]	10.91	9.13
Residual	9.67[6]	5.79[6]	8.83	7.29
Liquid Gases	9.69	NA	10.28	8.58
Natural Gas	7.88	6.05	8.49	7.31
Electricity	19.37	23.12	20.90	21.61
Industrial Sector				
Distillate	11.02	7.79	10.68	8.93
Residual	9.67[6]	5.79	8.53	7.06
Liquid Gases	9.73	NA	10.28	8.58
Natural Gas	6.95	5.72	8.00	6.35
Coal	2.60[6]	2.19	2.05	2.03
Electricity	13.91	19.41	15.20	15.67
Transportation Sector				
Gasoline	15.24	12.16	14.68	12.85
Distillate	11.45[6]	7.79[6]	12.07	10.10
Residual	9.18	5.79[6]	8.53	7.06
Jet Fuel	12.05	8.33	11.55	9.50

1/ Energy Information Administration, *1981 Annual Report to Congress*, DOE/EIA-0173(81)/3, Vol. 3 of 3, February 1982, pages 154-155, converted to 1981 dollars.

2/ Data Resources, Inc., *Energy Review*, Summer 1982, page 177.

3/ National Energy Policy Plan, "Energy Projections to the Year 2000," DOE/PE-0029, Policy, Planning and Analysis, U.S. Department of Energy, July 1981, page 3-3.

4/ Midrange scenario and markups.

5/ U.S. average refiner acquisition cost of imported crude oil.

6/ Fuel price is not differentiated by sector.

NA: Not Available

FUEL PRICES BY SECTOR AND BY WORLD OIL PRICE CASE

- High and low world oil prices (see Section 2) are projected to have a substantial effect on petroleum product prices and, due to substitutability in many uses, natural gas prices.

- Although less dramatic, electricity prices are also affected due to higher primary fuel costs and a shift in the mix of fuels used.

- With such a large untapped supply, changes in the world oil price have little noticable effect on domestic delivered coal prices.

TABLE 3-3

FUEL PRICES BY SECTOR AND BY WORLD OIL PRICE CASE
(1981 Dollars Per Million Btu's)

	PROJECTED							
	1985		1990		1995		2000	
	LOW WOP	HIGH WOP	LOW WOP	HIGH WOP	LOW WOP	HIGH WOP	LOW WOP	HIGH WOP
WORLD OIL PRICE1/ (1981 $/barrel)	27.50	37.00	31.50	57.00	41.00	71.00	51.00	74.00
RESOURCE PRICES								
Refiner Crude Oil	4.75	6.37	5.44	9.84	7.07	12.24	8.77	12.67
Wellhead Gas	3.30	4.09	4.08	6.84	5.26	8.16	6.61	7.77
Minemouth Coal	1.34	1.38	1.45	1.45	1.54	1.58	1.64	1.67
DELIVERED PRICES								
Residential Sector								
Distillate	6.93	8.80	7.72	12.82	9.61	15.59	11.58	16.09
Liquid Gases	6.11	7.72	6.79	11.18	8.42	13.57	10.12	14.00
Natural Gas	5.67	6.58	6.28	9.26	7.56	10.68	9.01	10.26
Electricity	18.72	19.19	20.07	21.43	22.57	24.21	22.72	23.93
Commercial Sector								
Distillate	6.31	8.07	7.06	11.85	8.84	14.47	10.69	14.93
Residual	4.86	6.38	5.51	9.65	7.04	11.90	8.64	12.30
Liquid Gases	5.90	7.58	6.62	11.18	8.31	13.67	10.07	14.11
Natural Gas	5.35	6.26	5.99	8.96	7.26	10.38	8.71	9.96
Electricity	19.51	19.99	21.12	22.56	23.87	25.61	24.12	25.40
Industrial Sector								
Distillate	6.21	7.91	6.93	11.57	8.65	14.10	10.45	14.55
Residual	4.72	6.18	5.35	9.32	6.82	11.48	8.35	11.87
Liquid Gases	5.90	7.58	6.62	11.18	8.31	13.67	10.07	14.11
Natural Gas	4.38	5.25	5.05	7.97	6.26	9.32	7.67	8.89
Coal	1.83	1.87	2.02	2.02	2.14	2.18	2.26	2.30
Electricity	13.75	14.09	15.32	16.36	17.59	18.87	17.96	18.91
Transportation Sector								
Gasoline	9.99	11.78	10.75	15.62	12.56	18.26	14.44	18.74
Distillate2/	6.99	8.94	7.82	13.11	9.78	16.00	11.83	16.51
Residual	4.72	6.18	5.35	9.32	6.82	11.48	8.35	11.87
Jet Fuel2/	6.25	8.28	7.12	12.64	9.17	15.65	11.30	16.19

1/ U.S. average refiner acquisition cost of imported crude oil.
2/ Excludes taxes.

FUEL PRICES BY SECTOR AND BY MARKUP ASSUMPTION

- As defined here, a markup is the price difference between the resource and delivered price of a fuel.
- Table 3-4 shows a range of delivered fuel prices produced by leaving resource prices at midrange values and varying the markup.
- The range on petroleum product markups was derived by changing the estimated markup up and down by two projected standard deviations from the linear regression analysis used to generate the midrange estimates.
- The largest standard deviation (and thus uncertainty) is associated with residential liquid petroleum gases. The smallest uncertainty is associated with residential distillate.
- The range on other delivered price markups were estimated to cover approximately the same confidence interval as the range on petroleum product markups.

TABLE 3-4

FUEL PRICES BY SECTOR AND BY MARKUP ASSUMPTION1/
(1981 Dollars Per Million Btu's)

	PROJECTED							
	1985		1990		1995		2000	
	LOW MU	HIGH MU	LOW MU	HIGH MU	LOW MU	HIGH MU	LOW MU	HIGH MU
WORLD OIL PRICE2/ (1981 $/barrel)	32.5	32.5	42.5	42.5	53.5	53.5	62.0	62.0
RESOURCE PRICES								
Refiner Crude Oil	5.58	5.58	7.34	7.34	9.25	9.25	10.69	10.69
Wellhead Gas	3.71	3.71	5.31	5.31	6.45	6.45	7.26	7.26
Minemouth Coal	1.36	1.36	1.46	1.46	1.58	1.58	1.66	1.66
DELIVERED PRICES								
Residential Sector								
Distillate	7.51	8.26	9.47	10.37	11.61	12.66	13.22	14.39
Liquid Gases	5.52	8.35	6.97	10.41	8.54	12.64	9.74	14.33
Natural Gas	6.11	6.18	7.53	7.68	8.74	8.94	9.60	9.82
Electricity	18.41	19.48	19.64	21.44	22.06	24.51	22.03	24.70
Commercial Sector								
Distillate	6.85	7.57	8.69	9.56	10.69	11.73	12.20	13.36
Residual	4.89	6.39	6.40	8.19	8.04	10.14	9.28	11.61
Liquid Gases	5.50	8.02	7.06	10.11	8.75	12.38	10.03	14.10
Natural Gas	5.78	5.85	7.27	7.35	8.47	8.61	9.34	9.49
Electricity	19.55	19.91	21.31	21.91	24.23	25.06	24.35	25.24
Industrial Sector								
Distillate	6.67	7.49	8.43	9.43	10.35	11.55	11.80	13.14
Residual	4.60	6.34	6.03	8.09	7.58	9.99	8.75	11.43
Liquid Gases	5.50	8.02	7.06	10.11	8.75	12.38	10.03	14.10
Natural Gas	4.78	4.88	6.28	6.42	7.41	7.63	8.24	8.47
Coal	1.38	2.34	1.49	2.57	1.60	2.74	1.69	2.89
Electricity	13.41	14.41	14.76	16.56	16.88	19.46	17.00	19.93
Transportation Sector								
Gasoline	9.40	12.41	11.07	14.63	12.89	17.03	14.27	18.84
Distillate3/	5.12	10.97	6.86	13.49	8.75	16.22	10.17	18.29
Residual	4.60	6.34	6.03	8.09	7.58	9.99	8.75	11.43
Jet Fuel3/	6.17	8.42	8.19	10.81	10.38	13.42	12.04	15.39

1/ "Markup" is defined here as the price difference between the resource and delivered price of a fuel.

2/ U.S. average refiner acquisition cost of imported crude oil.

3/ Excludes taxes.

SECTION 4: DOMESTIC ENERGY CONSUMPTION

This section discusses the NEPP projections of domestic energy consumption through the year 2000. End-use consumption of energy is projected as a function of changes in real GNP and energy prices. The consumption projections are presented both for the medium price case (or midrange) and for a range of consumption, which is derived by varying GNP growth rates.

The midrange energy demand projections calculate the total of net energy demand by fuel type (direct oil, gas, coal, renewables, and electricity). Because the model used for the projections does not calculate sectoral energy demands internally, the sectoral breakdowns described here were developed via other existing demand models (particularly the Energy Information Administration's latest projections), individual sectoral demand studies, and informed judgment.

In the tables in Section 4, end-use energy categories include liquids, gases, coal solids, renewables and electricity. Liquids include products from shale oil and coal synthetics. Gases include synthetic gas from coal. Coal solids do not include coal consumed to produce synthetic oil and gas. Renewables include 1.8 quads of biomass not usually accounted for in most other energy data and projections. Finally, electricity is delivered electricity after losses for conversion, transmission and distribution.

AGGREGATE ENERGY CONSUMPTION TRENDS

- Table 4-1 shows some aggregate projections of energy consumption and growth, as well as the base case assumptions of economic growth and energy prices. The most significant trends presented here involve the relationship between primary energy demand, end-use demand and economic growth.
- The ratio of primary energy growth to real GNP growth is projected to be about 0.55 from 1981 to 2000, continuing a trend beginning with the 1973 oil embargo. This will be maintained due to increased energy prices curtailing demand and stimulating conservation, as delivered energy prices grow at an annual rate of 2.6 percent through the year 2000. The largest growth occurs from 1985 to 1990 as most remaining domestic energy price controls are lifted, mainly from the Natural Gas Policy Act of 1978 (NGPA).
- Primary energy demand is expected to grow faster than end-use demand (1.4 percent per annum versus 0.8 percent per annum) from 1981 through 2000 due to increased conversion losses associated with increasing electricity demand (2.8 percent per annum) and increasing use of coal conversion for liquids and gases in the late 1980's and 1990's.

TABLE 4-1

AGGREGATE ENERGY CONSUMPTION TRENDS

			PROJECTED			
	1980	1981	1[illegible] MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
U.S. GNP (trillion 1972 dollars)	1.48	1.51	1.68	1.96	2.2	2.42
U.S. GNP Growth Rate (%/year from 1981)	--	--	2.7	2.9	2.7	2.5
Population (millions)	222.5	224.5	233.2	243.8	253	260.7
GNP Per Capita (1972 dollars)	6652	6726	7204	8066	8696	9283
Primary Energy Consumption (quads/year)	77.7	75.7	80.7	87.0	92.0	97.0
Btu's Per GNP (Btu's/1972 dollar)	52,500	50,132	48,037	44,388	41,818	40,083
Ratio of Primary Energy Growth to GNP Growth (growth from 1981)	--	--	0.61	0.54	0.53	0.54
Average Delivered Energy Price (1981 $/MMBtu)	7.4	8.1	8.43	10.28	12.1	13.1
End-Use Energy Consumption (quads/year)	60.4	58.2	60.7	63.2	65.5	67.4

END-USE FUEL CONSUMPTION

- Table 4-2 shows the projected energy use in quads for each fuel type and sector. Trends in shifting away from oil towards other energy forms are apparent in all sectors. The transportation sector actually declines in energy consumption due to increased vehicle efficiency and the turnover of inefficient automobiles from before 1980.
- Overall end-use consumption grows slowly (less than 1 percent per year through 2000), mainly due to increased efficiencies and conservation in response to long run real energy price increases.

TABLE 4-2

END-USE FUEL CONSUMPTION
(Quadrillion Btu's Per Year)

	1980	1981[1]	PROJECTED			
			1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
RESIDENTIAL/COMMERCIAL						
Liquids	4.2	4.0	4.0	3.8	3.6	3.3
Gases	7.6	7.4	7.3	7.4	7.4	7.6
Coal Solids	0.2	0.2	0.2	0.2	0.2	0.2
Renewables	0.2	0.3	0.5	0.6	0.8	0.9
Electricity	4.4	4.4	4.8	5.5	6.3	7.2
Subtotal	16.5	16.2	16.8	17.4	18.2	19.2
INDUSTRIAL						
Liquids	8.3	7.3	7.6	8.4	8.3	7.9
Gases	8.4	8.0	9.1	9.5	9.9	10.0
Coal Solids	3.2	3.1	3.8	4.3	5.1	5.9
Renewables	1.6	1.6	1.6	1.9	2.2	2.6
Electricity	2.8	2.8	3.4	4.2	4.5	5.0
Subtotal	24.3	22.8	25.6	28.2	30.0	31.4
TRANSPORTATION						
Liquids	19.0	18.5	17.5	16.6	16.2	15.8
Gases	0.6	0.6	0.6	0.7	0.7	0.8
Renewables (Alcohol)	--	--	0.1	0.1	0.2	0.2
Subtotal	19.6	19.1	18.2	17.4	17.1	16.8
FUEL SUBTOTALS						
Liquids	31.5	29.8	29.1	28.8	28.1	27.0
Gases	16.5	16.0	17.1	17.5	18.0	18.3
Coal Solids	3.4	3.3	4.0	4.5	5.3	6.1
Renewables	1.8	1.9	2.2	2.6	3.2	3.7
Electricity	7.1	7.2	8.3	9.8	10.9	12.3
TOTAL END-USE CONSUMPTION[2]	60.4	58.2	60.7	63.2	65.5	67.4

---

[1] Energy Information Administration, *Monthly Energy Review*, DOE/EIA-0035(82/05), May 1981, pages 22-24, plus about 1.8 quads of biomass not included in DOE/EIA statistics. Asphalt included in commercial sector.

[2] Totals may not add due to rounding.

SENSITIVITY OF AGGREGATE ENERGY CONSUMPTION TO GNP

- Table 4-3 shows how the consumption and mix of fuels changes when assumptions about GNP are changed. While many factors affect energy demand and fuel use, especially energy prices and supply availability of specific fuels, GNP is a major uncertainty found to be a sensitive and important variable in determining energy demand.
- By the year 2000, end-use consumption may vary by as much as 13 quads when GNP growth is varied by a plus or minus 0.6 percent per year from 1981.
- The most petroleum liquids variance occurs in the transportation sector as lower incomes curtail driving habits and new, more efficient automobile purchases, while coal varies most in the industrial sector where investment in coal burning facilities may be significantly affected by sluggish or rapid economic growth.

TABLE 4-3.

SENSITIVITY OF AGGREGATE ENERGY CONSUMPTION TO GNP
(Quadrillion Btu's Per Year)

	PROJECTED							
	1985		1990		1995		2000	
	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP
GNP GROWTH RATE (%/year from 1981)	1.8	3.5	2.3	3.5	2.1	3.2	1.9	3.1
RESIDENTIAL/COMMERCIAL								
Liquids	3.9	4.2	3.6	4.0	3.4	3.8	3.1	3.4
Gases	7.1	7.5	7.2	7.6	7.3	7.9	7.0	8.6
Coals	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Renewables	0.5	0.5	0.6	0.6	0.8	0.9	0.8	1.0
Electricity	4.7	5.0	5.1	5.8	6.1	6.8	6.3	8.0
Subtotal	16.4	17.4	16.8	1.82	17.8	19.6	17.4	21.2
INDUSTRIAL								
Liquids	7.3	7.8	8.4	8.9	8.1	8.7	7.5	8.1
Gases	9.0	9.4	9.0	9.7	9.6	10.6	8.9	11.6
Coals	3.8	4.1	4.0	4.5	4.9	5.5	5.3	6.5
Renewables	1.6	1.6	1.9	2.0	2.3	2.3	2.4	2.8
Electricity	3.1	3.6	3.7	4.6	4.1	5.2	4.0	6.1
Subtotal	24.8	26.5	27.0	29.7	29.0	32.3	28.1	35.1
TRANSPORTATION								
Liquids	17.1	18.0	15.5	17.2	15.8	17.2	15.0	16.7
Gases	0.6	0.6	0.6	0.7	0.6	0.7	0.6	0.9
Renewables (Alcohol)	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
Subtotal	17.8	18.7	16.2	18.0	16.6	18.1	15.8	17.8
FUEL SUBTOTALS								
Liquids	28.3	30.0	27.4	30.2	27.4	29.6	25.6	28.2
Gases	16.6	17.4	16.7	17.9	17.5	19.2	16.5	21.0
Coals	3.9	4.2	4.3	4.7	5.1	5.7	5.5	6.7
Renewables	2.2	2.2	2.6	2.7	3.2	3.4	3.4	4.0
Electricity	7.8	8.7	8.9	10.4	10.3	12.2	10.3	14.2
TOTAL END-USE CONSUMPTION[1/]	58.8	62.5	59.9	65.9	63.5	70.1	61.3	74.2

1/ Totals may not add due to rounding.

RESIDENTIAL AND COMMERCIAL FUEL USE

- Table 4-4 shows the projected demand by sector and fuel type through the year 2000 for the residential and commercial sectors.

- Residential energy demand is projected to grow at only a 0.4 percent rate through the year 2000, while commercial energy demand is projected to grow at 4 times that rate, about 1.5 percent per annum. This is mainly due to two factors. The first is the increasing importance of the services sector of the economy, causing commercial floor space to grow at about the same rate as GNP, 2.7 percent per annum to the year 2000, while population growth and households are expected to grow much slower, with households only growing at a 1.9 percent annual rate. The second factor is that residential energy consumption is more price sensitive since energy is a higher percentage of household expenditures than commercial business costs.

TABLE 4-4

RESIDENTIAL AND COMMERCIAL FUEL USE1/
(Quadrillion Btu's Per Year)

				PROJECTED			
		1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
SECTOR	FUEL TYPE						
Residential							
	Liquids	2.1	2.0	1.8	1.7	1.4	1.2
	Gases	4.9	4.8	4.5	4.4	4.3	4.3
	Coals	0.1	0.1	0.1	0.1	0.1	0.1
	Renewables	0.2	0.3	0.4	0.5	0.6	0.7
	Electricity	2.4	2.4	2.7	3.0	3.5	4.0
	Subtotal	9.7	9.6	9.4	9.6	10.0	10.4
Commercial							
	Total Liquids	2.1	2.0	2.2	2.2	2.1	2.1
	Refined	1.2	1.1	0.9	0.7	0.6	0.5
	Asphalt	0.9	0.8	1.3	1.4	1.5	1.6
	Gases	2.6	2.6	2.9	3.0	3.1	3.2
	Coals	0.1	0.1	0.1	0.1	0.1	0.1
	Renewables	--	--	0.1	0.1	0.2	0.2
	Electricity	2.0	2.0	2.1	2.5	2.8	3.2
	Subtotal	6.8	6.6	7.4	7.8	8.3	8.8
Total Fuel Consumption							
	Liquids	4.2	4.0	4.0	3.8	3.6	3.3
	Gases	7.6	7.4	7.3	7.4	7.4	7.6
	Coals	0.2	0.2	0.2	0.2	0.2	0.2
	Renewables	0.2	0.3	0.5	0.6	0.8	0.9
	Electricity	4.4	4.4	4.8	5.5	6.3	7.2
GRAND TOTAL		16.5	16.2	16.8	17.4	18.2	19.2

1/ Totals may not add due to rounding.

RESIDENTIAL AND COMMERCIAL TRENDS

- Table 4-5 shows the expected trends in household and commercial floor space growth and the projected energy use per unit in these sectors. Mainly due to increased efficiency in space conditioning, the energy use per household and per square foot commercial floor space drop at annual rates of 1.7 and 1.5 percent through the year 2000.

TABLE 4-5

RESIDENTIAL AND COMMERCIAL TRENDS

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
RESIDENTIAL						
Households (millions)	78.4	79.2	85.1	93.7	103.6	114.4
Energy Use per Household (10^6 Btu/year)	124.0	121.3	110.5	101.7	96.0	90.6
COMMERCIAL						
Commercial Floor Space (billions of sq. ft.)	31.8	32.5	36.4	41.6	47.6	54.5
Energy Use Per Commercial Square Foot1/ (10^6 Btu/year)	0.185	0.178	0.168	0.154	0.143	0.132

1/ Asphalt excluded from commercial sector when computing energy use per square foot.

INDUSTRIAL ENERGY DEMAND

Energy use in the industrial sector is expected to increase through the year 2000 at a slower rate than GNP growth, with the fastest growth occurring before 1990 coinciding with the expected growth in GNP.

Historical fuel demand by functional type is available, but the allocation of specific fuel usage within each function for 1980 and 1981 is judgmental, since 1974 is the most recent year for which detailed data on industrial fuel use are available. These specific fuel type assignments are based on the 1974 fuel use patterns. The seperation of electricity in "other use" refers to machine drive and electrolytic processes inherently different from the other categories presented.

INDUSTRIAL FUEL USE

Table 4-6 shows the fuel use projections by fuel type and industrial sector through 2000, with each sector showing distinctly different trends in fuel use mix.

Major Fuel Burning Installations (MFBI)

Large boilers (more than 100 MMBtu's per hour energy input), can be fired by most fuel types since steam is the desired output. This allows for maximum ability to switch fuel. Many have oil and gas dual capabilities. National emphasis on domestic energy use and coal's price and supply advantages will make it the preferred large boiler fuel by 2000, replacing more expensive oil and gas which has been historically unreliable due to controls (see Table 4-7).

Small Boilers and Process Heaters (SBPH)

Small boilers and process heaters are expected to shift in energy use less dramatically than large boilers. Small boilers (less than 100 MMBtu's per hour energy input), are constrained in coal use by proportionally higher handling, storage and environmental costs than large boiler users. Process heaters (glass melters, drying ovens, chemical and petroleum tubestill heaters, kilns, etc.) are constrained in coal use by the need for an even, clean, close proximity flame which is difficult using direct coal. Here, the trend is only a small shift away from gas and oil towards coal, renewables and electricity (see Table 4-7).

Feedstocks

Industrial feedstock energy use is dominated by oil and gas used by the petrochemical industry. Metallurgical coal use is related to industrial steelmaking and the demand for coking fuel. Coal demand in feedstocks for coking is expected to remain relatively constant.

Projecting the total amount, as well as the fuel mix, for oil and gas use in feedstocks is difficult. While fuel costs are a higher percentage of product costs than in other industries making their demand more fuel price sensitive, substitutes for these products and fuel are often not available counteracting the price effects. The projection of oil and gas use in feedstocks shows growth slightly less than GNP, about 2.2 percent per annum to the year 2000.

TABLE 4-6

INDUSTRIAL FUEL USE
(Quadrillion Btu's Per Year)

			PROJECTED			
	1980	1981[1]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
MFBI[2]						
Liquids	0.8	0.6	0.7	0.6	0.5	0.3
Gases	2.8	2.6	2.7	2.5	2.4	2.2
Coals	0.7	0.7	1.0	1.4	1.8	2.5
Renewables	0.4	0.4	0.4	0.5	0.7	0.9
Subtotal	4.7	4.3	4.8	5.0	5.4	5.8
SMALL BOILERS AND PROCESS HEATERS						
Liquids	3.9	3.5	3.7	3.9	3.5	2.6
Gases	4.7	4.6	5.3	5.6	6.2	6.4
Coals	0.7	0.7	0.9	1.2	1.3	1.6
Renewables	1.2	1.2	1.2	1.4	1.5	1.7
Electricity	0.1	0.1	0.2	0.3	0.4	0.5
Subtotal	10.6	10.1	11.3	12.4	12.8	12.9
FEEDSTOCKS						
Liquids	3.6	3.2	3.2	3.8	4.4	5.0
Gases	0.9	0.8	1.1	1.3	1.4	1.5
Met Coals	1.8	1.8	1.9	1.9	1.9	1.9
Subtotal	6.3	5.6	6.3	7.0	7.8	8.4
OTHER USES						
Electricity[3]	2.7	2.7	3.2	3.9	4.1	4.5
SUBTOTALS						
Liquids	8.3	7.3	7.6	8.4	8.3	7.9
Gases	8.4	8.0	9.1	9.5	9.9	10.0
Coals	3.2	3.1	3.8	4.3	5.1	5.9
Renewables	1.6	1.6	1.6	1.9	2.2	2.6
Electricity	2.8	2.8	3.4	4.2	4.5	5.0
TOTAL INDUSTRIAL FUEL USE[4]	24.3	22.8	25.6	28.2	30.0	31.4

---

[1] Subtotals based on 1973-78 trends. Breakdown by functional use category is judgmental using the EIA Energy Consumption Data Base (1974) for reference.

[2] Boilers with more than 100 million Btu's per hour of input.

[3] Primarily machine-drive and electrolytic uses of electricity.

[4] Totals may not add due to rounding. Asphalt included in commercial sector.

NEW MAJOR FUEL BURNING INSTALLATION (MFBI) AND SMALL BOILER AND PROCESS HEATER (SBPH) ADDITIONS BY FUEL TYPE

- Table 4-7 details the growth trends and shifts in energy use by large and small boilers by examining the assumed market penetration of new equipment in each category. Due to increasing substitutability of oil and gas they are presented here together.

- In the MFBI category, oil drops dramatically from 47 percent of new installations to 17 percent by the year 2000. Coal increases its market share to 61 percent in 2000, while renewables, mainly in the form of biomass in the energy intensive paper industry, increases its share considerably.

- The disadvantages in coal use for the SBPH category are apparent here as oil and gas remain dominant with a 62 percent market share in 2000. Biomass renewables show significant gains in small boiler use while electricity, although expensive, has excellent heat control, cleanliness and reliability allowing it to maintain a small share of the process heaters market.

TABLE 4-7

NEW MAJOR FUEL BURNING INSTALLATION (MFBI) AND SMALL BOILER AND PROCESS HEATER (SBPH) ADDITIONS BY FUEL TYPE[1]

FUEL TYPE	1980-1985		1985-1990		1990-2000	
	MFBI	SBPH	MFBI	SBPH	MFBI	SBPH
Oil and Gas	47%	76%	27%	68%	17%	62%
Coal	45%	10%	57%	14%	61%	16%
Renewables	7%	9%	17%	13%	23%	16%
Electricity	0%	5%	0%	5%	0%	6%
TOTAL[2]	100%	100%	100%	100%	100%	100%

---

[1] Assumes that large boilers have an average lifetime of 30 years and that process heaters have an average lifetime of 25 years.

[2] Totals may not add due to rounding.

TRANSPORTATION FUEL USE

- Table 4-8 summarizes projected fuel consumption for the transportation sector through the year 2000.
- A total reduction in demand for energy is projected due to the increased efficiency of the fleet overcomming the effect of larger stocks of cars and vehicle miles driven. The greatest reduction in fuel demand occurs before 1990, as the older pre-1980 vehicles are retired while new models attain large efficiency gains. After 1990, the efficiency gains are more modest, but slower population growth in the 1990's reduces the growth in demand for cars and vehicle miles.
- There is a significant shift in fuel use as diesel fuel use becomes a much higher percentage of the passenger car and light truck fuel use.

TABLE 4-8

TRANSPORTATION FUEL USE
(Quadrillion Btu's Per Year)

	1980	1981[1]	PROJECTED 1985 MIDRANGE	 1990 MIDRANGE	 1995 MIDRANGE	 2000 MIDRANGE
FUEL TYPE						
Motor Gasoline	12.4	12.4	10.5	8.8	7.9	7.0
Distillate	2.8	2.7	3.2	4.4	4.9	5.3
Jet Fuel	2.2	2.0	2.3	2.2	2.2	2.3
Residual Oil	1.4	1.2	1.1	1.0	1.0	1.0
Other[2]	0.2	0.2	0.2	0.2	0.2	0.2
Oil Subtotal	19.0	18.5	17.5	16.6	16.2	15.8
Alcohol Fuels	--	--	0.1	0.1	0.2	0.2
Gases	0.6	0.6	0.6	0.7	0.7	0.8
GRAND TOTAL[3]	19.6	19.1	18.2	17.4	17.1	16.8

1/ 1980 and 1981 from Energy Information Administration, 1981 Annual Report to Congress, DOE/EIA-0173(81)/2, Volume II, February 1982, page 69 and Monthly Energy Review, DOE/EIA-0035(82/05), May 1981, page 24.
2/ Includes aviation gasoline, liquefied gases, and lubricants.
3/ Totals may not add due to rounding.

SALIENT STATISTICS FOR TRANSPORTATION SECTOR

- Table 4-9 shows the breakdown between passenger automobiles and light and heavy trucks, as well as other important factors in transportation fuel use, such as vehicle miles and efficiency.
- These factors are affected by fuel prices, economic factors and government policies. Vehicle miles driven and new car purchases are sensitive to economic factors and fuel prices, while efficiency of vehicles can be affected by fuel prices and government standards.
- Some of the reduction in fuel use in the passenger automobiles fleet is offset by the increased use of light and heavy trucks which show more modest efficiency gains.

TABLE 4-11

SALIENT STATISTICS FOR TRANSPORTATION SECTOR

			PROJECTED			
	1980	1981[1]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
FUEL TYPE						
Passenger Auto Fleet						
Registrations (millions)	104	104	108	114	125	131
Road MPG (fleet average)	15.2	15.9	19.3	24.8	30.0	35
EPA MPG (fleet average)	17.3	18.1	23.3	31.7	37.3	39
Vehicle Miles Traveled (10^9)	1116	1124	1224	1332	1497	1601
Vehicle Miles per Vehicle (10^3)	10.7	10.8	11.3	11.7	12	12.2
Fuel Consumed by Fleet (quads)	9.2	8.9	7.6	6.8	6.4	5.8
Light Trucks						
Registrations (millions)	29.3	29.8	32	38	42	47
Road MPG (fleet average)	10.5	10.9	14.1	16.9	19.9	22.3
Vehicle Miles Traveled (10^9)	209	211	311	375	423	482
Vehicle Miles per Vehicle (10^3)	7.1	7.1	9.7	9.9	10	10.3
Fuel Consumed by Fleet (quads)	2.5	2.4	2.8	2.8	2.7	2.7
Medium and Heavy Trucks						
Registrations (millions)	4.4	4.2	4.3	4.5	4.7	5.2
Road MPG (fleet average)	5.3	5.3	6.0	6.8	7.0	7.1
Vehicle Miles Traveled (10^9)	98.4	99.3	108	126	137	155
Vehicle Miles per Vehicle (10^3)	22.4	23.6	25.1	28	29	29.8
Fuel Consumed by Fleet (quads)	2.5	2.6	2.4	2.4	2.7	3.0

---

[1] 1980 and 1981 from Highway Fuel Consumption Model, 7th quarterly report, Energy and Environmental Analysis, Inc. April 1982, page B-1.

COMPARISON WITH OTHER PROJECTIONS

- Table 4-10 compares the July 1982 midrange demand projections with projections of demand by other studies. Some projections have been altered to add 1.8 quads of biomass renewables (when not originally accounted for) to permit comparison with the July 1982 midrange projections.

TABLE 4-10

COMPARISON OF 1990 ENERGY END-USE DEMAND PROJECTIONS
(Quadrillion Btu's Per Year)

	JULY 1982 MIDRANGE	TEXACO[1]	EIA[2]	DRI[3]
RESIDENTIAL/COMMERCIAL				
Liquids	3.8	4.5	3.7	2.8
Gases	7.4	9.7	7.0	7.3
Coals	0.2	0.1	0.1	0.2
Renewables	0.6	0.2[4]	0.2[4]	0.1
Electricity	5.5	5.1	5.4	5.7
Other	--	--	--	--
Subtotal	17.4	19.6	17.4	16.1
INDUSTRIAL				
Liquids	8.4	9.7	6.7	8.5
Gases	9.5	7.8	9.2	8.5
Coals	4.3	5.7	5.6	4.8
Renewables	1.9	1.6[4]	1.6[4]	--
Electricity	4.2	4.4	3.9	3.5
Other	--	--	2.9	--
Subtotal	28.2	29.2	29.9	25.3
TRANSPORTATION				
Liquids	16.6	18.8	16.6	17.4
Gases	0.7	--	0.5	0.5
Renewables	0.1	--	--	--
Other	--	--	1.1	--
Subtotal	17.4	18.8	18.2	17.9
FUEL SUBTOTALS				
Liquids	28.8	33.0	27.0	28.7
Gases	17.5	17.5	16.7	16.3
Coals	4.5	5.8	5.7	5.0
Renewables	2.6	1.8[4]	1.8[4]	0.1
Electricity	9.8	9.5	9.3	9.2
Other	--	--	4.0	--
TOTAL END-USE CONSUMPTION	63.2	67.6	64.5	59.3

1/ Texaco Company, United States Energy Outlook: 1980-2000, Finance and Economics Department, February 1981, Appendix Tables.

2/ Energy Information Administration, 1981 Annual Report to Congress, DOE/EIA-0173(81)/3, Volume III, February 1982, pages 152-153.

3/ Data Resources, Inc., Energy Review, Summer 1982, inside front cover.

4/ 1.8 quads of renewable energy consumption added to make projections comparable.

SECTION 5: DOMESTIC OIL, GAS AND SYNTHETICS SUPPLY

Two variables account for most of the uncertainty in projecting conventional oil and natural gas production:

- The size of the nation's remaining recoverable resource base; and
- The future path of world oil and other energy prices.

The size of the remaining resource base determines returns-to-drilling or the amount discovered per foot drilled. As less oil or gas remains undiscovered it becomes increasingly difficult, and expensive, to find, prove and produce additional reserves.

The price of crude oil affects production of both oil and natural gas primarily through the producers' decisions to drill. As prices rise, increased profits encourage more intensive drilling in known areas and additional exploration in new and frontier areas.

Other factors may also affect future oil, gas and synthetics production. For example, there may be unforseen changes in leasing or environmental constraints, or in the availability of rigs and manpower. The cost and ability to expand production of synthetic fuels are other uncertainties.

Changes in any of the above assumptions could significantly alter the midrange projections presented in this section.

U.S. OIL SUPPLY

- Table 5-1 shows projected U.S. oil supply from 1980 through 2000.
- The decline in Lower-48 conventional oil production is offset to a large extent by increased oil production in North Alaska and from enhanced oil recovery, shale oil and coal liquids.
- Since domestic oil consumption drops faster than oil production, net oil imports decline over the projection timeframe inspite of the 14 percent drop in U.S. oil production between 1981 and 2000.

TABLE 5-1

U.S. OIL SUPPLY
(Million Barrels Per Day)[1]

			PROJECTED			
	1980	1981[2]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
DOMESTIC OIL PRODUCTION						
Conventional Oil						
Lower-48[3]	7.1	7.0	6.4	5.3	4.8	3.9
North Alaskan	1.5	1.5	1.6	1.7	1.7	1.8
Enhanced Oil[4]	—	—	0.2	0.5	1.0	1.3
Shale	--	--	--	0.1	0.2	0.5
Natural Gas Liquids	1.6	1.6	1.4	1.1	0.8	0.6
Subtotal	10.2	10.2	9.5	8.7	8.6	8.2
Synthetic Coal Liquids	--	--	--	0.1	0.2	0.4
TOTAL LIQUIDS PRODUCTION	10.2	10.2	9.5	8.8	8.8	8.6
REFINERY GAIN	0.6	0.5	0.5	0.5	0.4	0.4
NET IMPORTS[5]	6.3	5.1	5.8	6.0	5.3	4.6
STOCK DRAWDOWN (BUILD)	(0.1)	0.1	--	--	--	--
TOTAL SUPPLY	17.0	15.9	15.7	15.2	14.4	13.7

1/ Conversion factors of 2.117 quads per million barrels per day (MMBD) for conventional, enhanced, shale, and coal liquids, and 1.444 quads per MMBD for natural gas liquids.

2/ Energy Information Administration, "Short-Term Energy Outlook," DOE/EIA-0202 (82/2Q)-1, May 1982, page 17.

3/ Includes South Alaska production of approximately 0.1 MMBD in 1980.

4/ Incremental tertiary production. California heavy oil currently produced with thermal recovery techniques (0.3 MMBD in 1980) included under Conventional Lower-48.

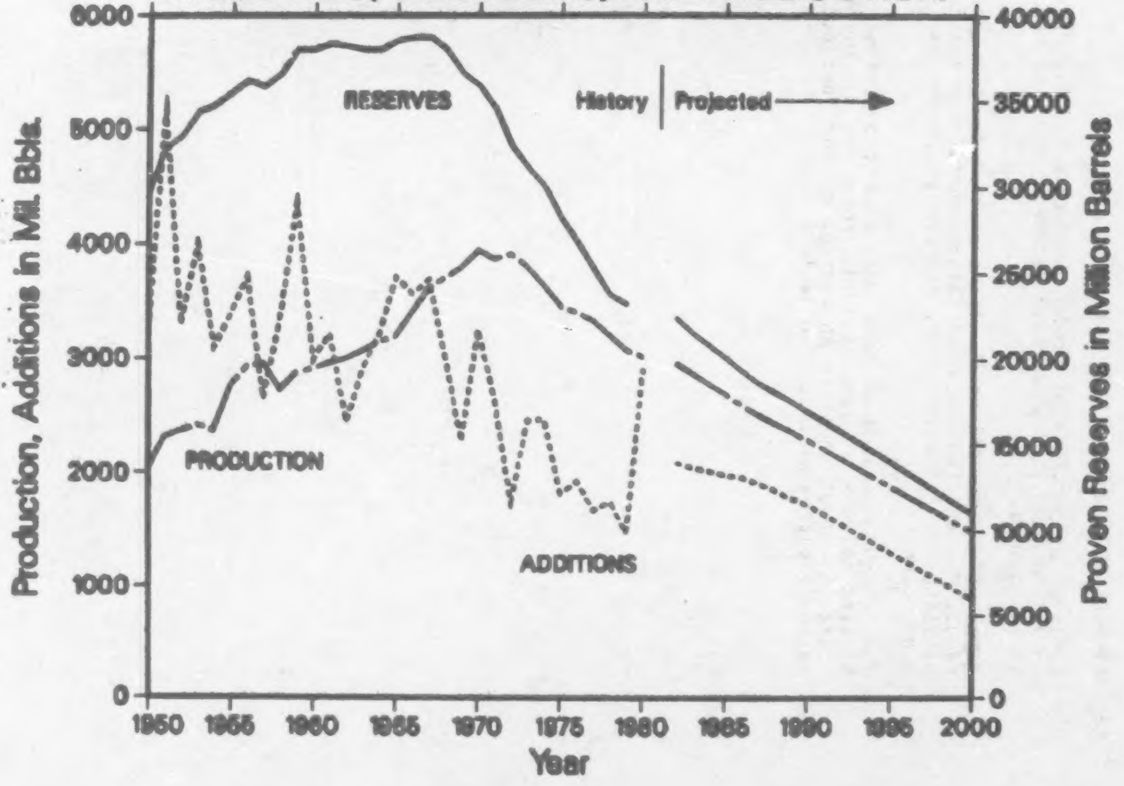
5/ Net U.S. crude and petroleum product imports, excluding net imports for the Strategic Petroleum Reserve and imports by U.S. territories.

LOWER-48 CRUDE OIL AND NGL RESERVES, ADDITIONS AND PRODUCTION

- Figure 5-1 shows historical and projected Lower-48 crude oil and natural gas liquids production, reserves and reserve additions. The figure is useful for comparing the July 1982 projections with historical trends.
- The excess of production over reserve additions causes proven reserves to decline throughout the projection period.
- Sources for history are:
  - API, AGA and CPA, *Reserves of Crude Oil, Natural Gas Liquids and Natural Gas in the United States and Canada as of December 31, 1978*; and
  - EIA, *U.S. Crude Oil and Natural Gas Reserves, 1978, 1979 and 1980 Annual Reports*.

Figure 5-1

LOWER 48 CRUDE OIL and NGL
RESERVES, ADDITIONS, and PRODUCTION



ESTIMATES OF RECOVERABLE CRUDE OIL

- Long-run projections of production are primarily dependent on the amount of economically recoverable crude oil still in the ground.

- Alternative assumptions about the size of the resource base result in substantially different paths for returns-to-drilling, drilling activity, reserve additions and annual production.

- The assumption used in the July 1982 projections of 69 billion barrels of remaining oil resources in the United States is about equal to an average of the four published resource estimates listed in Table 5-2.

TABLE 5-2

ESTIMATES OF RECOVERABLE CRUDE OIL[1]
(Billions of Barrels)

EXXON[2]	45
RAND[3]	59
SHELL[4]	70
USGS 1981[5]	103
JULY 1982 ASSUMPTIONS	
Midrange	69
Range	55-103

---

[1] Includes estimated quantities of recoverable, indicated, and inferred crude oil reserves and undiscovered resources. Estimates adjusted to reflect production through year-end 1979.

[2] Original Exxon estimates prepared in May 1976; adjusted to reflect a downward revision of undiscovered offshore resources to less than the USGS Circular 725 estimate of 26 billion barrels (August 1979 telephone conversation with Exxon). Excludes an estimated 50 billion barrels of enhanced oil recovery (EOR).

[3] _Discovery of Significant Oil and Gas Fields in the United States_, Rand study by Richard Nehring, January 1981. Includes offshore estimates for depths to 1,000 meters; includes some EOR.

[4] Shell estimates prepared in April 1979.

[5] USGS Circular 725, dated 1975; updated with undiscovered recoverable resource estimates from USGS preliminary report 81-192, published in 1981. Includes resources in depths from 0 to 2500 meters.

COMPARATIVE PROJECTIONS OF U.S. OIL PRODUCTION IN 1990

- The July 1982 projection of U.S. liquids production in 1990 is toward the low end of the range of projections shows in Table 5-3.
- Most of the difference between the July 1982 projections and the projections of EIA and DRI stems from a more conservative estimate of enhanced oil recovery in the July 1982 projections.

TABLE 5-3

COMPARATIVE PROJECTIONS OF U.S. OIL PRODUCTION IN 1990

(Million Barrels Per Day)

	JULY 1982 MIDRANGE	NEPP[1]	EIA[2]	TEXACO[3]	DRI[4]
Conventional Oil	7.0	7.0	7.2	7.2[5]	7.0
Enhanced Oil	0.5	0.6	1.0	--[6]	1.3
Natural Gas Liquids	1.1	1.1	1.3	1.0	1.3
Subtotal	8.6	8.7	9.5	8.2	9.6
Shale Oil	0.1	0.2	0.3	0.3	--
Synthetic Coal Liquids	0.1	0.2	--	0.2	--
Subtotal Synthetics	0.2	0.4	0.3	0.5	--
TOTAL DOMESTIC PRODUCTION (Not including refinery gain)	8.8	9.1	9.8	8.7	9.7

1/ National Energy Policy Plan, "Energy Projections to the Year 2000," DOE/PE-0029, Policy, Planning and Analysis, U.S. Department of Energy, July 1981, page 5-2.

2/ Energy Information Administration, 1981 Annual Report to Congress, DOE/EIA-0173(81)/3, Vol. 3 of 3, February 1982, pages 160-161.

3/ Texaco, "United States Energy Outlook: 1980-2000," Finance and Economics Department, Economics Division, Appendix Tables, February 1981.

4/ Data Resources, Inc., Energy Review, Summer 1982. page 97.

5/ Includes enhanced oil recovery.

6/ Included under conventional oil category.

U.S. NATURAL GAS SUPPLY

- The projections of natural gas production in Table 5-4 are based on the assumption that natural gas prices are deregulated in accordance with the Natural Gas Policy Act (NGPA).
- Production of associated dissolved gas depends generally on the level of crude oil production. Production of non-associated gas is projected independently of petroleum production.
- The Alaskan Natural Gas Pipeline is expected to come on-line in 1989 and provide 0.8 Tcf of North Alaskan gas.

TABLE 5-4

U.S. NATURAL GAS SUPPLY
(Trillion Cubic Feet Per Year)[1]

			PROJECTED			
	1980	1981[2]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
Conventional						
Lower-48[3]	19.1	18.9	18.2	16.2	15.1	14.0
North Alaska	--	--	--	0.8	0.8	0.8
Subtotal	19.1	18.9	18.2	17.0	15.9	14.8
Unconventional[4]	--	--	--	1.1	1.6	2.4
Subtotal	19.1	18.9	18.2	18.0	17.5	17.2
Gas Synthetics[5]	0.1	0.1	0.2	0.2	0.3	0.5
TOTAL DOMESTIC PRODUCTION	19.2	19.1	18.5	18.1	17.8	17.7
NET IMPORTS	0.9	0.8	1.2	1.8	2.1	2.2
STOCK DRAWDOWN (BUILD)	--	(0.3)	--	--	--	--
TOTAL SUPPLY	20.2	19.6	19.6	20.0	20.0	19.9

---

[1] Conversion factor of 1,021 Btu per standard cubic foot. Totals may not add due to rounding.

[2] Energy Information Administration, "Short-Term Energy Outlook," DOE/EIA-0202 (82/2Q)-1, May 1982, page 25.

[3] Includes South Alaska production of approximately 0.2 Tcf per year in 1980, increasing to 0.5 Tcf per year by 2000.

[4] Incremental production from tight sands, Devonian shale, coal bed methane, and geopressurized methane. Tight sands production from previously developed areas (0.9 Tcf in 1980) included under Conventional Lower-48.

[5] Synthetic gas from oil and coal.

ESTIMATES OF INFERRED AND UNDISCOVERED GAS RESOURCES

- Over the long-term, total conventional gas production depends most heavily on the actual volume of resources trapped underground (the recoverable, but still partially undiscovered resource base).

- The range in the July 1982 estimates corresponds to the 95 percent and 5 percent confidence intervals estimated by the U.S. Geological Survey (USGS).

TABLE 5-5

ESTIMATES OF INFERRED AND UNDISCOVERED GAS RESOURCES[1]

(Trillions of Cubic Feet)

RAND[2]	196
PGC[3]	913
EXXON[4]	342
SHELL[5]	326
USGS[6]	740
JULY 1982 ASSUMPTIONS	
Midrange	740
Range	621-885

---

[1] Adjusted to reflect additions to proved reserves through year-end 1979 or later, as noted.

[2] Discovery of Significant Oil and Gas Fields in the United States. Rand, January 1981. Includes offshore estimates for depths to 1,000 meters.

[3] Potential Supply of Natural Gas in the United States, as of December 31, 1982. Potential Gas Committee, May 18, 1981. Offshore estimates to 1,000 meters.

[4] U.S. Oil and Gas Potential, Exxon, March 1976.

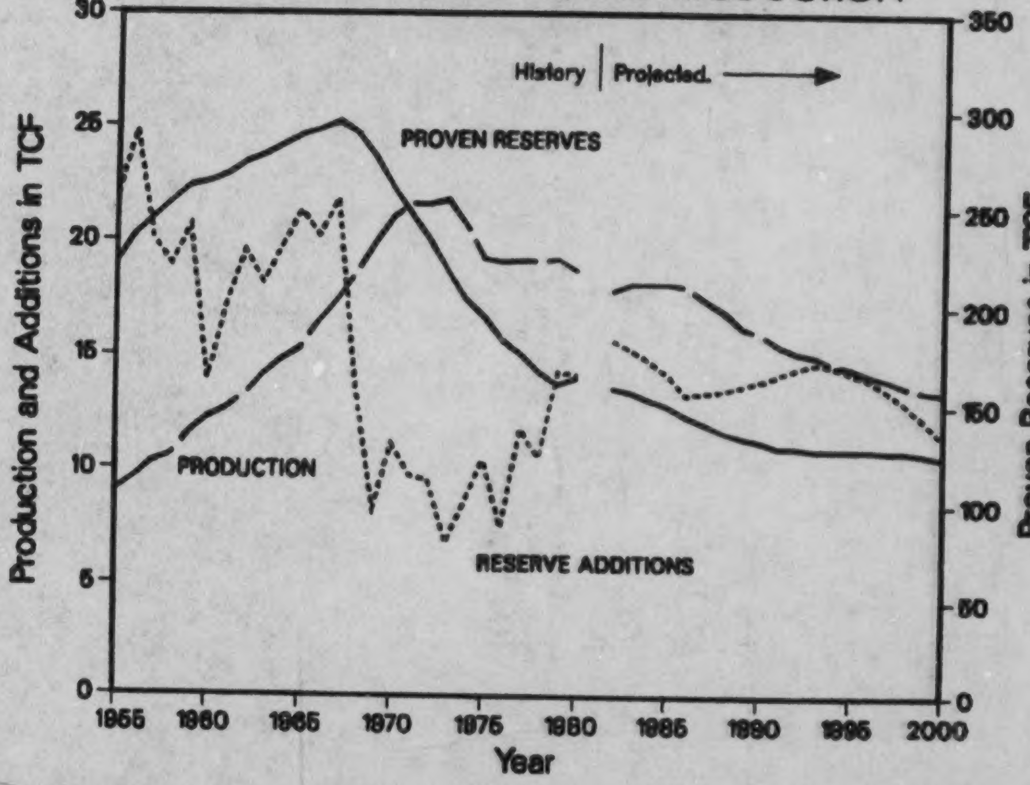
[5] Shell Oil estimate, prepared in April 1979.

[6] USGS Circular 725, 1975 (updated with USGS preliminary report 81-192, 1981). Includes offshore resource estimates for depths to 2500 meters.

LOWER-48 NATURAL GAS RESERVES, ADDITIONS AND PRODUCTION

- Figure 5-2 plots historical and projected Lower-48 conventional natural gas production, reserves and reserve additions. The figure is useful for illustrating how the projections compare with historical trends.
- Cumulative drilling footage is expected to total about 5 billion feet, but returns-to-drilling are expected to decline over the 20 year period. This leads to generally decreasing additions to reserves between now and the year 2000.

Figure 5-2
LOWER 48 NATURAL GAS
RESERVES, ADDITIONS, and PRODUCTION



UNCONVENTIONAL GAS

- The projections of unconventional gas production shown in Table 5-6 depend on assumptions of price, costs and geology.
- The estimate of recoverable unconventional gas resources is based on a review of other studies. Our estimate falls on the low side of a range from less than 100 Tcf (Gas Research Institute, 1980) to more than 1000 Tcf (National Petroleum Council, 1980). The higher estimates reflect higher prices and more rapid technological development than were assumed here.
- There is almost no firm information or experience to suggest how much of the existing geopressurized brine under the earth's surface would actually yield natural gas in economically viable quantities.
- Compared to tight sands, investment in Devonian shale is considered somewhat riskier, particularly because of the lack of data and experience with the latter technology.
- Given the nation's coal resources, a large amount of coal-bed gas must be trapped in underground seams. The economic recoverability of much of this gas is questionable, however.

TABLE 5-6

UNCONVENTIONAL GAS RESOURCES AND INCREMENTAL PRODUCTION

	PROJECTED INCREMENTAL PRODUCTION[1] (Tcf/year)		RESOURCES (Tcf)
	1990	2000	
SOURCES			
Tight Sands	0.7	1.8	150
Devonian Shale	0.3	0.4	25
Coal Seams	0.1	0.2	25
Geopressurized Brine	--	--	NA
TOTAL	1.1	2.4	200

---

[1] Incremental production; not including 0.8 Tcf of production from tight sands and 0.1 Tcf from Devonian shale from fields already developed as of 1980.

COMPARATIVE PROJECTIONS OF U.S. GAS PRODUCTION IN 1990

- The July 1982 projections of natural gas production are slightly higher than other recent projections.
- The July 1982 projections are about 0.8 Tcf lower in 1990 compared to NEPP primarily due to a more conservative estimate of the demand and availability of natural gas in the residential/commercial and industrial markets.

TABLE 5-7

COMPARATIVE PROJECTIONS OF U.S. GAS PRODUCTION IN 1990
(Trillion Cubic Feet Per Year)

	JULY 1982 MIDRANGE	NEPP[1]	EIA[2]	DRI[3]	TEXACO[4]
Conventional	17.0	17.1	15.8	16.8	16.1
Unconventional[5]	1.1	1.3	1.7	NA	NA
Gas Synthetics[6]	0.2	0.5	0.1	0.3	1.0
TOTAL DOMESTIC PRODUCTION	18.1	18.9	17.6	17.1	17.1

1/ National Energy Policy Plan, "Energy Projections to the Year 2000," DOE/PE-0029, Policy, Planning and Analysis, U.S. Department of Energy, July 1981, page 6-2.

2/ Energy Information Administration, 1981 Annual Report to Congress, DOE/EIA-0173(81)/3, Vol. 3 of 3, February 1982, page 162.

3/ Data Resources, Inc., Energy Review, Summer 1982, page 126.

4/ Texaco, "United States Energy Outlook: 1980-2000," Finance and Economics Department, Economics Division, Appendix Tables, February 1981.

5/ Incremental production from tight sands, Devonian shale, coal bed methane, and geopressurized methane.

6/ Synthetic gas from naphtha and coal.

SYNTHETIC FUELS

- Of the two primary sources of synthetic liquids, coal liquids and shale oil, shale oil is perhaps the more viable technology in the near-term because of its relative advantage in both cost and readiness.
- Shale oil production is likely to be limited over the longer term by regional and environmental considerations to a total production level of roughly 1.2 MMBD or less.
- These projections take into account the activities of the Synthetic Fuels Corporation (SFC) and include consideration of SFC actions through May, 1982.

TABLE 5-8

SYNTHETIC FUELS PRODUCTION: 1985-2000
(Thousand Barrels Per Day of Oil Equivalent)

	PROJECTED[1]							
	1985		1990		1995		2000	
	MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE	MIDRANGE	RANGE
LIQUIDS								
Shale Oil	10	0-50	80	10-375	230	50-650	500	200-1200
Coal Liquids	0	0-20	70	25-150	150	40-425	360	75-1200
Liquids from Biomass	25	0-50	50	0-100	90	10-160	140	50-250
Liquids Subtotal	35	0-120	200	35-625	470	100-1235	1000	325-2650
GASES								
High-Btu Gas	10	0-20	40	0-125	70	10-200	100	50-300
Medium/Low Btu Gas	5	0-15	30	10-55	80	30-130	150	100-300
Gases Subtotal	15	0-35	70	10-180	150	40-330	250	150-600
TOTAL SYNTHETICS	50	0-155	270	45-805	620	140-1565	1250	475-3250

---

[1] Totals may not add due to rounding.

ASSUMPTIONS FOR SYNTHETIC FUEL TECHNOLOGIES

- Table 5-9 provides some estimates of key assumptions which significantly affect projections of synthetic fuels production.
- The midrange minimum acceptable prices shown in Table 5-9 are not an average of the low and high ends of the ranges in prices since the distribution of possible price outcomes is skewed. Very high prices are possible, but only with a low probability of occurance.

TABLE 5-9

ASSUMPTIONS FOR SYNTHETIC FUEL TECHNOLOGIES

	SHALE OIL	COAL LIQUIDS	LOW/MEDIUM Btu GAS	HIGH Btu GAS
Minimum Acceptable Price[1/] (1981$/Barrel Crude Oil Equivalent)				
Midrange	40	50	45	50
Range	35-60	40-80	40-65	40-75
Conversion Efficiency (Btu out/Btu in)	NA	0.5-0.6	0.65-0.75	0.6-0.7
Average Construction Time (Years)	6-11	6-11	6-11	6-11

[1/] Economic cost of production, including capital costs, feedstock costs, and adjustments for risk.

SECTION 6: DOMESTIC COAL SUPPLY

This section presents alternative projections of coal production and consumption from 1980 through 2000. Future U.S. coal production will depend primarily on coal demand. Only under cases of extremely high coal demand should the capacity to produce or transport coal become an overall constraint. For example, existing coal mines and transportation infrastructure have the capacity to produce and deliver about 900 million tons of coal per year, which is about 80 million tons per year above 1981 coal production. The excess coal production capacity should allow coal supply to meet rising coal demand through 1990 with only a moderate expansion in production facilities.

U.S. COAL PRODUCTION AND CONSUMPTION

- Each of several factors--land reclamation, environmental controls, health and safety regulation, leasing and transportation--could add to the projected price of coal and could significantly affect projected coal demand and supply.

- While the primary direct use of coal is in the industrial sector, this category includes a small amount (about 0.2 to 0.3 quads of mostly anthracite) consumed by the residential and commercial sectors throughout the projection period. More detail on industrial coal consumption is available in Section 4.

- For ranges in coal consumption, see the high and low economic growth scenarios reported in Section 4 on energy demand (page 4-7) and Section 9 on electricity supply (page 9-5).

TABLE 6-1

U.S. COAL PRODUCTION AND CONSUMPTION
(Million Tons Per Year)[1]

			PROJECTED			
	1980	1981[2]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
CONSUMPTION						
Synfuels						
Liquids	--	--	--	10	22	40
Gases	--	--	3	10	22	60
Subtotal	--	--	3	20	45	100
Direct Use	133	132	165	190	220	255
Utilities	569	597	680	825	955	1100
TOTAL CONSUMPTION[3]	703	729	850	1035	1225	1455
NET EXPORTS						
Metallurgical Coal	65	65	65	70	70	70
Steam Coal	25	36	65	70	140	155
Subtotal	90	111	130	140	210	225
STOCK INCREASE (DECREASE)	34	(20)	--	--	--	--
TOTAL PRODUCTION[3]	830	820	980	1175	1435	1680

---

[1] The following conversion rates were used: 22.5 MMBtu's per ton for synfuels; 24.0 MMBtu's per ton for direct use; 21.3 MMBtu's per ton for utilities; 26.0 MMBtu's per ton for metallurgical coal exports; 22.5 MMBtu's per ton for steam coal exports. Numbers rounded to nearest 5 million tons.

[2] Energy Information Administration, "Short-Term Energy Outlook," DOE/EIA-0202 (82/2Q)-1, May 1982, page 26.

[3] Totals may not add due to rounding.

COMPARISON OF COAL PROJECTIONS FOR 1990

- The July 1982 midrange projections are in line with the other projections reported in Table 6-2.
- In comparing the July 1982 coal projections to the NEPP projections, the largest differences are the 40 million ton per year drop in direct coal use and the 40 million ton per year drop in coal for synthetic fuels. Both reductions are due primarily to lower world oil prices in the July 1982 projections which reduces the competitive advantage of direct and coal synthetics compared to conventional oil and natural gas.
- There is also a 40 million ton per year increase in coal consumption by utilities in the July 1982 projections compared with NEPP. About half of the increase is due to a slightly lower projection of nuclear energy production in the July 1982 projections and about half due to slightly more rapid growth in overall electricity demand in the July 1982 projections compared with NEPP.

TABLE 6-2

COMPARISON OF COAL PROJECTIONS FOR 1990
(Million Tons Per Year)

	EIA[1/]	DRI[2/]	NCA[3/]	NEPP[4/] MIDRANGE	JULY 1982 MIDRANGE
DOMESTIC CONSUMPTION					
Direct Use	236	216	219	230	190
Utilities	835	803	868	785	825
Synthetic Fuels	18	10	10	60	20
TOTAL CONSUMPTION	1089	1029	1097	1070	1035
NET EXPORTS	143	158	138	145	140
TOTAL PRODUCTION	1232	1193[2/]	1235	1215	1175

1/ Energy Information Administration, *1981 Annual Report to Congress*, DOE/EIA-0173(81)/3, Vol. 3 of 3, February 1982, page 164.

2/ Data Resources, Inc., *Energy Review*, Summer 1982, total production includes 5.7 million tons coal stock increase, page 144.

3/ National Coal Association, "Looking Ahead to 1995," April 1982, page 4.

4/ National Energy Policy Plan, "Energy Projections to the Year 2000," DOE/PE-0029, Policy, Planning and Analysis, U.S. Department of Energy, July 1981, page 7-2.

SECTION 7: DOMESTIC NUCLEAR SUPPLY

This section summarizes projections of nuclear power growth in the United States. Through 1990, the projections are based on plant-by-plant analyses which are prepared by the Energy Information Administration (EIA) and updated each year.

In the near-term the projections reflect delays in acquiring new capacity which have arisen following the Three Mile Island accident. In addition, deferrals and cancellations of new capacity have taken place recently because of lower projections of electricity demand growth, financial constraints on utilities, higher construction costs and continuing delays and uncertainties in permitting and licensing.

The projections provided here reflect midrange results. Much higher or lower nuclear capacity could result under alternative assumptions. To illustrate some of the uncertainty affecting nuclear capacity projections, this section provides analysis of how changes in assumptions about U.S. economic growth affect projections of nuclear capacity.

TABLE 7-1

STATUS OF NUCLEAR POWERPLANTS[1]
(as of March 1, 1982)

	GIGAWATTS[2]
Existing Capacity On-Line[3]	57
Significant Construction Complete	65
Subtotal Firm or Committed Capacity	122
Construction Permit Granted but Construction Not Started or Not Significantly Complete	16
Plants Ordered or Under Construction Permit Review	10
Total Surveyed Capacity	148

---

[1] Based on Energy Information Administration, U.S. Commercial Nuclear Power, DOE/EIA-0315, March 1982, page 17.

[2] One gigawatt is equal to 1000 megawatts.

[3] Fully operable or in power ascension. Does not include Indian Point 1 (265 MWe), Humboldt Bay (65 MWe), Three Mile Island 2 (906 MWe) and Dresdan (200 MWe)--all of which are currently shut down indefinitely.

TABLE 7-2

U.S. NUCLEAR POWER PROJECTIONS[1]
(Gigawatts-Electric--GWe)

	1980	1981	PROJECTED 1985	1990	1995	2000
EIA 1981 Annual Report						
Midrange	55	57	90	121	136	165
Range			86-98	116-124	123-142	145-185
July 1982 Midrange	55	57	90	121	136	157
July 1982 Scenarios[2]						
High GNP	--	--	90	128	154	169
Low GNP	--	--	80	107	130	130

---

[1] End-of-year capacity.

[2] Electricity growth rates 1981-2000 are as follows:

Midrange	2.8%/year
High GNP	3.6%/year
Low GNP	1.9%/year

KEY NUCLEAR ASSUMPTIONS

- The range in nuclear capacity in the high and low GNP scenarios is a function of changing demand for electricity in general rather than a change in the relative cost or availability of nuclear energy.
- Although the EIA 1981 Annual Report and the July 1982 projections shown in Table 7-2 indicate the same nuclear generating capacity on-line in 1985, 1990 and 1995, estimates of primary energy displaced differ due to differing assumptions about capacity factors and conversion rates.
- Additional delays in licensing or other deferrals could cause actual capacity to be less than that projected. Conversely, streamlining of regulatory processes and/or relief of utility financial difficulties could cause additional capacity to come on-line faster than projected.

TABLE 7-3

KEY NUCLEAR ASSUMPTIONS

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
GNP Growth Rate (%/year from 1981)	--	--	2.7	2.9	2.7	2.5
Electricity Demand Growth Rate (%/year from 1981)	--	--	3.6	3.4	3.0	2.8
Total Electricity Consumption						
(Trillion kWh)	2.1	2.1	2.4	2.9	3.2	3.6
(Quadrillion Btu's)	7.1	7.2	8.3	9.8	10.9	12.3
Electricity Produced by Nuclear Plants1/						
(Trillion kWh)	0.25	0.27	0.46	0.68	0.78	0.87
(Quadrillion Btu's)	0.86	0.93	1.6	2.3	2.7	3.0
Primary Energy2/ Displaced by Nuclear Power (Quadrillion Btu's)	2.7	2.9	4.9	7.3	8.3	9.2

1/ Electricity generated at the busbar.
2/ Assumes heat rate of 10,640 Btu/kWh.

SECTION 8: DOMESTIC RENEWABLES SUPPLY

Renewable energy technologies are grouped into two major categories:

- o Central-Electric technologies used to generate electricity in central-station power plants; and
- o Dispersed technologies used directly by end-use consumers.

Central-electric data are presented in terms of the equivalent primary energy inputs required to generate electricity in conventional steam-turbine plants. Dispersed renewable energy technologies (which provide heating, cooling, process energy, liquid fuels, or even small amounts of electricity--but directly for end-use applications) include solar hot water heating, agricultural and industrial process heat, alcohol fuels, and small wind systems. The contribution of passive solar energy systems (which range from window shades to architectural and site modifications) is also included under this heading--even though "passive solar" might more properly be considered an aspect of energy conservation, rather than of energy supply.

Dispersed renewables data cannot easily be presented in terms of the equivalent primary energy displaced because it is not always possible to determine which conventional fuel form is being displaced in a given application. To be precise one would have to know what fuel the consumer would have purchased and how it would have been used. Conversion efficiency figures vary widely. For example, when passive solar energy displaces electric resistance space heating, the amount of primary fuel displaced is approximately three times the end-use value (conversion efficiency of 32 percent). Electric heat pumps, on the other hand, may have heating efficiencies of more than 200 percent, so a passive solar system used in place of a heat pump displaces substantially less primary energy in that particular application. When the same passive solar heating system displaces an oil- or gas-fired system, the primary energy displaced equals about 1.4 times the end-use value (assuming a conversion efficiency for the conventional burner of 70 percent). These projections, therefore, present the central-electric renewable projections in terms of the primary energy displaced, but dispersed renewable projections are represented in terms of the end-use energy delivered. On average, this may understate somewhat the dispersed renewable contribution as a replacement of primary energy.

RENEWABLE ENERGY PRODUCTION

- Two major renewable energy sources, high-head hydro and biomass constituted about 95 percent of the total renewable energy produced in 1981. Although these sources are expected to maintain their dominance for the remainder of this century, their share will decrease to about 64 percent as other renewable technologies (low-head hydro, geothermal, wind, active and passive solar space conditioning and process heating) mature and achieve significant market penetrations.

- Major cost and technical feasibility uncertainties affect renewables projections. Other factors such as the future cost of competing energy sources, rate of economic growth and consumer acceptance of new energy technologies in the market place also affect future renewable energy consumption. Thus, the role of renewables in the national energy equation is highly uncertain. Renewables could develop from a currently modest contribution to become a significant energy supply source by 2000, depending on factors which are impossible to quantify at this time.

TABLE 8-1

RENEWABLE ENERGY PRODUCTION
(Primary Quadrillion Btu's Per Year)[1]

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
CENTRAL-ELECTRIC						
High-Head Hydro[2]	2.9	2.7	2.95	3.0	3.1	3.2
Low-Head Hydro	0.05	0.05	0.1	0.2	0.4	0.5
Geothermal	0.05	0.05	0.1	0.2	0.3	0.4
Photovoltaics	--	--	--	0.01	0.04	0.1
Wind	--	--	--	0.03	0.4	0.7
OTEC[3]	--	--	--	--	--	--
Solar Thermal	--	--	--	--	--	0.1
Biomass	0.03	0.03	0.05	0.1	0.2	0.3
TOTAL CENTRAL-ELECTRIC[4]	3.0	2.9	3.2	3.5	4.4	5.4
End-Use Quadrillion Btu's Per Year[1]						
DISPERSED						
Biomass[5]	1.8	1.8	1.9	2.1	2.4	2.6
Active Solar Heating and Cooling	--	--	0.05	0.1	0.15	0.17
Passive Solar Heating and Cooling	0.05	0.10	0.20	0.25	0.30	0.35
Agricultural and Industrial Process Heat	--	--	0.05	0.11	0.19	0.3
Geothermal Direct Heat	--	--	--	0.06	0.12	0.2
Wind	--	--	--	0.02	0.05	0.07
Photovoltaics	--	--	--	0.01	0.02	0.03
TOTAL DISPERSED[4]	1.8	1.9	2.2	2.6	3.2	3.7
TOTAL RENEWABLES[4]	4.8	4.8	5.4	6.1	7.6	9.1

---

[1] Renewable energy used by central-electric technologies is represented as primary energy inputs to electric utility powerplants. Renewable energy used in dispersed applications is represented as the actual end-use energy delivered in its final fuel form.

[2] In the NEPP projections provided in July 1981, high-head hydro was defined to include 0.2 quads of electricity imports which are not included in this definition of high-head hydro.

[3] OTEC--Ocean Thermal Energy Conversion.

[4] Totals may not add due to rounding.

[5] Includes the use of biomass in the pulp and paper industries and residential space heat not currently accounted for in most other DOE/EIA statistics.

BIOMASS ENERGY

- The major current use of biomass energy is in the pulp and paper industry as a source of process heat. Wood and wood waste are readily available and have traditionally provided a major energy source to that industry. Statistics on this particular form of biomass energy have only recently become of interest and were not generally included in most reports of national energy use.

- The potential for large scale increases in the use of biomass outside of the wood products industry is tempered by the comparatively high costs of gathering, transporting and processing biomass raw material.

- Modest increases in the use of wood for residential heating and grain for transportation fuels (alcohol) are anticipated. However, recent sales of gasohol have not kept pace with projections of anticipated markets, illustrating the difficulties of accurately projecting market penetrations for even relatively simple products. The potential of economically producing alcohol from wood is attractive, but depends on the industrial development of advanced processing techniques now in various stages of research.

- While biomass is a large potential source of renewable energy, the extent of additional use in coming years is highly uncertain and will depend on the development of economic and practical means of utilizing the resource.

TABLE 8-2

BIOMASS ENERGY CONSUMPTION
(Quadrillion Btu's Per Year)

			PROJECTED			
	1980	1981	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
CENTRAL-ELECTRIC BIOMASS1/	0.03	0.03	0.05	0.1	0.2	0.3
DISPERSED BIOMASS2/						
Industrial Process Heat	1.6	1.6	1.6	1.7	1.9	2.1
Residential Heat	0.15	0.17	0.2	0.25	0.29	0.32
Transportation Fuels	0.01	0.01	0.1	0.1	0.2	0.2
TOTAL DISPERSED BIOMASS3/	1.8	1.8	1.9	2.1	2.4	2.6
TOTAL BIOMASS3/	1.8	1.8	2.0	2.2	2.6	2.9

1/ Central-electric biomass is measured as the equivalent amount of primary energy inputs of other fuel types that would otherwise be required as inputs to electric utility powerplants.

2/ Dispersed biomass production is measured as the amount of actual end-use energy delivered in its final fuel form.

3/ Totals may not add due to rounding.

DISPERSED RENEWABLE ENERGY USE

- The pulp and paper industry currently accounts for almost 85 percent of the dispersed renewable energy consumed in the United States.
- Adequate technologies for solar space conditioning are now available and their market penetration could increase significantly over the next 20 years depending on the price of conventional alternatives, economic conditions affecting the construction of new residences and consumer preferences.
- Modest additional biomass use, geothermal and process heat applications are also anticipated, along with an expanding alcohol fuels industry. However, recent cancellation of considerable planned ethanol production capacity has increased the uncertainty of the projections.
- Significant dispersed energy production by wind and photovoltaic technologies is not expected before 2000.

TABLE 8-3

DISPERSED RENEWABLE ENERGY USE BY SECTOR[1/]
(Quadrillion Btu's Per Year)

	1980	1981	PROJECTED 1985 MIDRANGE	 1990 MIDRANGE	 1995 MIDRANGE	 2000 MIDRANGE
RESIDENTIAL/COMMERCIAL						
Biomass	0.15	0.17	0.2	0.25	0.3	0.32
Active Solar Heating and Cooling	--	--	0.05	0.1	0.15	0.17
Passive Solar Heating and Cooling	0.05	0.10	0.20	0.25	0.30	0.35
Wind	--	--	--	0.02	0.05	0.07
Photovoltaics	--	--	--	0.01	0.02	0.03
Subtotal	0.2	0.3	0.5	0.6	0.8	0.9
INDUSTRIAL						
Biomass	1.6	1.6	1.6	1.7	1.9	2.1
Agricultural/Industrial Process Heat	--	--	0.05	0.1	0.2	0.3
Geothermal	--	--	--	0.07	0.13	0.2
Subtotal	1.6	1.6	1.6	1.9	2.2	2.6
TRANSPORTATION						
(Alcohol Fuels from Biomass)	0.01	0.01	0.1	0.1	0.2	0.2
TOTAL DISPERSED RENEWABLES	1.8	1.9	2.2	2.6	3.2	3.7

1/ Dispersed renewable energy use is measured as the actual end-use energy delivered in its final fuel form. Totals may not add due to rounding.

SECTION 9: DOMESTIC ELECTRICITY SUPPLY

The domestic electricity projections provided in this section are based upon assumptions of existing government policies and programs. Enactment of new energy and/or economic policies could considerably alter the midrange projections.

This section deals with only some of the uncertainty underlying utility projections by providing high and low economic growth scenarios. The range in electricity demand and production by fuel varies considerably in response to changes in assumed U.S. economic growth.

Changes in many other assumptions could alter the July 1982 electricity projections from the midrange values. Some of the uncertainties include electricity demand by sector, the price of electricity and the effects of economic and financial conditions on utility investment.

Because of the many factors which could alter these projections, users are cautioned to interpret the projections as only one possible base case for planning purposes and that specific projects should be evaluated against a group of alternative scenarios.

ELECTRIC UTILITY ENERGY CONSUMPTION

- Table 9-1 summarizes projections of primary fuel inputs to electricity production for the 1980 to 2000 timeframe.
- Oil and gas inputs to electricity are projected to decline from about 25 percent of total primary inputs in 1980 and 1981 to equal only about 7 percent by 2000. Almost two thirds of this decline is projected to occur by 1990.
- Coal's contribution to primary inputs to electricity generation increases from about 51 percent in 1980 and 1981 to equal about 57 percent by 2000, while nuclear increases from about 11 percent in 1980 and 1981 to equal about 22 percent by 2000.
- Hydro/geothermal and renewables's share of primary inputs to electricity generation remains fairly constant as a fraction of total primary inputs increasing from about 12 percent in 1980 and 1981 to about 13 percent in 2000. This means that production of electricity from hydro/geothermal and renewables grows about the same rate as total primary electricity production.
- Electricity delivered to final consumers is projected to grow about 2.8 percent per year to 2000. Growth in the 1980's is somewhat more rapid than growth in the 1990's. The more rapid near-term growth is due to more rapid economic growth in the 1980's compared with the 1990's

TABLE 9-1

ELECTRIC UTILITY ENERGY CONSUMPTION
(Quadrillion Btu's Per Year)

			PROJECTED			
	1980	1981[1]	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
PRIMARY ENERGY CONSUMPTION						
Oil	2.6	2.2	2.3	1.8	1.3	1.0
Gas	3.8	3.7	2.9	2.9	2.4	2.0
Coal	12.1	12.7	14.6	17.6	20.4	23.5
Nuclear	2.7	2.9	4.9	7.3	8.3	9.2
Hydro/Geothermal	3.0	2.9	3.2	3.4	3.8	4.1
Renewables	--	--	--	0.1	0.6	1.3
TOTAL PRIMARY CONSUMPTION[2]	24.1	24.4	28.0	33.1	36.8	41.1
CONVERSION, TRANSMISSION AND DISTRIBUTION LOSSES	17.2	17.4	19.9	23.5	26.1	28.8
ELECTRICITY IMPORTS	0.1	0.1	0.1	0.1	0.1	0.1
ELECTRICITY SALES[3]						
(Quadrillion Btu's)	7.1	7.2	8.3	9.8	10.9	12.3
(Trillion kWh)	2.1	2.1	2.4	2.9	3.2	3.6
ELECTRICITY DEMAND GROWTH RATE (%/year from 1981)	--	--	3.6	3.4	3.0	2.8

---

[1] 1980 and 1981 from Energy Information Administration, "Short-Term Energy Outlook," DOE/EIA-0202(82/2Q)-1, May 1982, pages 27 and 28.

[2] Totals may not add due to rounding.

[3] Electricity delivered to final consumers, including net electricity imports.

GNP ASSUMPTIONS AND ELECTRIC UTILITY ENERGY CONSUMPTION

- Table 9-2 shows how alternative assumptions about the U.S. rate of economic growth affect electricity production and consumption.

- In the high GNP case, delivered electricity sales increase about 16 percent faster than the rate of economic growth over the 1981 to 2000 timeframe. When a lower rate of economic growth is assumed, electricity demand becomes more sluggish, averaging only about the same rate of growth as GNP over the same period. Lower economic growth implies worse economic and financial conditions and possibly higher electricity prices, thereby reducing electricity demand.

- In terms of fuel mix, a change in economic growth rate does little to affect oil, gas and hydro/geothermal. Oil and gas use under any economic growth assumption are kept to a minimum since oil and gas are very expensive fuels. Hydro/geothermal use is more affected by availability of suitable sites and is not strongly affected by economic growth.

- Coal, nuclear and renewables inputs to electricity production vary considerably with changes in economic growth. Since these fuels are the only sources of significant new capacity, it is not surprising that changes in economic growth would cause changes in electricity demand and lead to changes in investment in new coal, nuclear and renewables capacity.

TABLE 9-2

GNP ASSUMPTIONS AND ELECTRIC UTILITY ENERGY CONSUMPTION
(Quadrillion Btu's Per Year)

	PROJECTED							
	1985		1990		1995		2000	
	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP	LOW GNP	HIGH GNP
GNP GROWTH RATE (%/year from 1981)	1.8	3.5	2.3	3.5	2.1	3.2	1.9	3.1
PRIMARY ENERGY CONSUMPTION								
Oil	2.2	2.5	1.6	1.9	1.3	1.5	0.9	1.0
Gas	2.8	3.1	2.6	3.1	2.3	2.7	1.8	2.1
Coal	13.8	15.5	15.8	19.0	19.1	23.3	19.2	27.5
Nuclear	4.6	5.2	6.6	7.9	7.9	9.3	7.9	10.1
Hydro/Geothermal	3.2	3.2	3.4	3.4	3.8	3.8	4.1	4.1
Renewables	--	--	0.1	0.1	0.5	0.9	0.8	2.5
TOTAL PRIMARY CONSUMPTION1/	26.5	29.5	30.1	35.4	34.9	41.4	34.6	47.4
CONVERSION, TRANSMISSION AND DISTRIBUTION LOSSES	18.9	21.0	21.4	25.2	24.8	29.4	24.5	33.4
ELECTRICITY IMPORTS	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
ELECTRICITY SALES2/								
(Quadrillion Btu's)	7.8	8.7	8.9	10.4	10.3	12.2	10.3	14.2
(Trillion kWh)	2.3	2.5	2.6	3.1	3.0	3.6	3.0	4.2
ELECTRICITY DEMAND GROWTH RATE (%/year from 1981)	2.0	4.7	2.4	4.1	2.6	3.8	1.9	3.6

1/ Totals may not add due to rounding.
2/ Electricity delivered to final consumers, including net electricity imports.

PROJECTIONS OF COAL-FIRED GENERATING CAPACITY

- Table 9-3 provides information on projected coal-fired generating capacity over the 1980 to 2000 timeframe.
- The average system coal plant capacity factor shown in Table 9-3 is a derived result based on a separate analysis of the midrange estimate of available coal generating capacity in a future year and the midrange estimate of actual consumption of electricity from coal fired plants in that particular year.

TABLE 9-3

PROJECTIONS OF COAL-FIRED GENERATING CAPACITY
(Gigawatts Electric--GWe)

		PROJECTED			
	1980	1985 MIDRANGE	1990 MIDRANGE	1995 MIDRANGE	2000 MIDRANGE
Currently Existing Plants1/	249	243	231	225	216
Oil and Gas Conversions	--	10	15	15	15
New Capacity	--	36	87	140	193
Total Coal-Fired Capacity	249	289	333	380	424
Coal Consumption by Utilities					
(Quads/Year)	12.1	14.6	17.6	20.4	23.5
(Million Tons/Year)2/	569	680	825	955	1100
Average System Coal Plant Capacity Factor3/	0.53	0.54	0.57	0.57	0.59
Average Conversion Efficiency	0.32	0.32	0.32	0.32	0.32

1/ Coal-fired plants currently operating, less retirements occurring throughout the projection years.
2/ Converted at 21.3 million Btu's per ton.
3/ Newer baseload plants are assumed to run at an average capacity factor of 0.65.

Mr. **Mares**. Sir, I think the work that I have done to date would indicate that it will be well past the turn of the century before liquefaction of coal will come anywhere near being a meaningful substitute for liquids derived from other means.

So I think the question that we are dealing with—and it is a very important question—is what is the appropriate level of Federal spending and what is the timing that that is going to be benefiting the Nation, relative to all the other needs we have. We have a large number of needs, both within fossil energy as well as beyond fossil energy. When you try to evaluate all of those, you have to ask yourself what is the likely need, what is the payoff going to be, what are the options the Nation is going to have to fulfill the needs? I think that there are enough liquid fuel alternatives, and I think most forecasters would say that there are ways to produce liquids other than coal liquefaction. I do not have any problem with the relative amount of research that we are doing within the fossil energy program on coal liquefaction.

Mr. **Lewis**. How closely are you working with the SFC to provide the technical support in coal liquefaction?

Mr. **Mares**. We have a memorandum of understanding with them to provide whatever help, in our competence, that we can. But we are not nearly so constrained to that. We have good working relationships with them. If it is a short question that you can answer over the telephone, you certainly do not try to keep a time clock and charge them for it. We have a very positive, professional, good working relationship to assist them in whatever way they would like in which we have competency.

Mr. **Lewis**. Are you providing any staff support?

Mr. **Mares**. We have not detailed people, to the best of my knowledge, but when they ask for help, we provide it under the memorandum of understanding we have with them.

Mr. **Lewis**. This is probably not under your jurisdiction, and it is not under the jurisdiction of this committee, I understand, but I am going to raise the question anyway.

I share a great concern with a lot of the people that I come in contact with that we are not filling our strategic petroleum reserve at this point at a rate that we should.

Do you have any comments on that? If you want to buy time to do some of the technical things that you say you would like to do, and also the fact that you feel that some of these technical things may take you well out into the next century, it would seem that we would want to get that reserve filled up. Do you have any feelings on that?

Mr. **Mares**. I think our program is designed to enhance the technology base for the economy in general. The strategic petroleum reserve is designed to protect the Nation in the event of a sudden disruption in the availability.

Mr. **Lewis**. Exactly. That is what I am asking.

Mr. **Mares**. The time horizons that those two important Government programs are designed for are quite different.

Rather than taking up the time of the hearing—I know there is another witness—I would be happy to talk to you later about that, although I happen to think it is the right decision. I think that the needs that we have today as a Nation relative to protection against import are different than they were at the time the program was started and the goals were set for it.

So I think that is better use of your time if we addressed it separately.

Mr. **Lewis**. The better use of my time is to make sure we have the fuel to operate.

Mr. **Mares**. That is one of the things we are committed in our program to enhance our ability to use coal.

Mr. **Lewis**. I have one further question, Mr. Chairman. Would you explain to me why you completely depleted the budget on MHD?

Mr. **Mares**. I look at a program that would probably cost $500 million before you would have a first integrated proof of concept MHD test facility and in which we are supporting a couple of other technologies at a lower level of funding that are farther along. I ask myself, Is that the wisest use of taxpayers' dollars?, "and I say, no."

Mr. **Lewis**. You don't feel there is any future in that at this point, with the technology that we have been able to acquire?

Mr. **Mares**. That is correct. In terms of the relative priorities and where it is likely to go. It is not the only thing that addresses the need to enhance our ability to use coal more economically and environmentally effectively.

Mr. **Lewis**. I still come back to this coal, and you have still cut it 50 percent. I sure have a problem with that.

Mr. **Mares**. That was coal liquefaction.

Mr. **Lewis**. Coal liquefaction. I have problems with that. I will discuss that with you maybe at a future date.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Let me just say that I think the gentleman makes a very good point. You talk to the experts about how much oil we have left in the world, and it varies from about 3 to 4 years to as much as about 15 years. I think it behooves us, even if we do have an oil glut right now, that we do something about trying to develop these alternative energy sources.

Mr. **Bateman**. Mr. Chairman?

Mr. **Fuqua**. Mr. Bateman?

Mr. **Bateman**. I wonder if it is feasible for the Secretary or the Department of Energy to provide the committee with as many forecasts of our fossil fuel reserves from as many recognized sources as possible, because it is disturbing that you pick up one periodical and there is no problem any more; you pick up another and the problem is going to be right back where we were a few years ago in a few years.

I think being able to have all those figures before us and perhaps then to question the approaches taken by the various people who are doing the quantifying of reserves would be very helpful.

Mr. **Fuqua**. I am sure we can get that from the Department.

Mr. **Mares**. Absolutely.

[The information follows:]

SIZE OF DOMESTIC OIL AND GAS RESOURCES AS ESTIMATED BY VARIOUS AUTHORITIES

Forecasters of fossil fuel resources from various recognized sources are provided in the attached table.

SIZE OF DOMESTIC OIL AND GAS RESOURCES AS ESTIMATED BY VARIOUS AUTHORITIES

	Recoverable crude oil [1] (billion bbl)	Inferred and undiscovered gas resources [2] (trillion cubic ft)
Exxon	[3] 45	[4] 342
Rand [5]	59	196
Shell [6]	70	326
USGS [7]	103	740
PGS [8]		913

[1] Includes estimated quantities of recoverable, indicated, and inferred crude oil reserves and undiscovered resources. Estimates adjusted to reflect production through year-end 1979.

[2] Adjusted to reflect additions to proved reserves through year-end 1979 or later, as noted.

[3] Original Exxon estimates prepared in May 1976; adjusted to reflect a downward revision of undiscovered offshore resources to less than the USGS Circular 725 estimate of 26 billion barrels (August 1979 telephone conversation with Exxon). Excludes an estimated 50 billion barrels of enhanced oil recovery (EOR).

[4] U.S. Oil and Gas Potential, Exxon, March 1976.

[5] Discovery of Significant Oil and Gas Fields in the United States, Rand, January 1981. Includes offshore estimates for depths of 1,000 meters.

[6] Shell Oil estimate, prepared in April 1979.

[7] USGS Circular 725, 1985 (updated with USGS preliminary report 81-192, 1981). Includes offshore resource estimates for depths to 2,500 meters.

[8] Potential Supply of Natural Gas in the United States, as of December 31, 1982. Potential Gas Committee, May 18, 1981. Offshore estimates to 1,000 meters.

Mr. **Mares**. Mr. Chairman and members of the committee, I share your concern that we are not in a long-term surplus situation today in the amount of crude oil that will be available.

The focus of our program is to develop the technology that will provide the widest range of options to use the fossil fuels that are available to this country. One of them is petroleum. We do know where a lot of petroleum is. We do not know how to get it out of the ground economically today.

But, as I say, we have produced about a third of the petroleum that we have found, so there are two-thirds still in the ground. In a couple of cases, we know how to get it out. However, the process is not as economically attractive as we would like, although there are increasing numbers of enhanced oil recovery process being used commercially in this country.

I am not saying there is no need to continue to enhance our technical ability to have fuels and energy available to us.

Mr. **Fuqua**. Mr. Bateman?

Mr. **Bateman**. Mr. Chairman, I have no further questions.

Mr. **Fuqua**. Mr. Boucher?

Mr. **Boucher**. Thank you, Mr. Chairman.

Mr. Secretary, from a previous discussion, you know of my interest in developing coal and water mixtures and perhaps seeing those at some point in the future be a ready replacement for oil in the boilers of industries and utilities.

One of the technologies which in my view would help speed that day along is a coal cleaning technique which would help reduce the sulfur and ash contents. Can you tell me what level of funding your Department has provided for coal-cleaning technology in 1983 and what your projected level of funding for those technologies will be in 1984?

Mr. **Mares**. We were appropriated in our line item which we call coal preparation $8 million in fiscal year 1983, and we have requested $5 million in fiscal year 1984.

I might point out that in 1982 we had less than $3 million. We have recognized that we should be generally increasing the amount of funding in that area for the reasons that you described. It is something that would enhance our ability to use coal.

Mr. **Boucher**. Do you presently have contracts with private industries for coal-cleaning technologies, or are those contracts solely with public institutions such as universities?

Mr. **Mares**. We have, as I recollect, contracts with two different private firms to do bench-scale, proof-of-concept types of research relating to some advanced coal-cleaning concepts. We try in all of our programs to use a variety of performers—industry, national labs, universities, and the energy technology centers.

Mr. **Boucher**. I thought that I saw in the budget for fossil fuel research that there was to be no funding for university-related research in the fossil fuel field for 1984. Was I correct in that?

Mr. **Mares**. No, sir, quite to the contrary. In fact, that was one of the subjects where we had requested more money than was appropriated last year. I want to repeat: We requested more money than was appropriated last year in the university coal research programs. I think we were appropriated at $2.75 million and we requested $4 million, so that is a rather substantial percentage increase.

Mr. **Boucher**. And that is all in fossil fuel?

Mr. **Mares**. It is all coal related.

Mr. **Boucher**. All right. And for 1984, can you tell me what your university research-related figure would be?

Mr. **Mares**. I think our estimates would be that the total amount would be about 8 percent of our budget, but we have not identified each of the individual universities or national labs or industries that we would in fact contract with within the proposed budget.

What I am giving you is an expectation based upon what we have done in fact in the past 2 years, coupled with my view that we should try to have all those players. If anything, I would think that universities might go up a little bit in 1984 as a percent—not an absolute, but as a percent—of our total budget.

Mr. **Boucher**. All right. Thank you, sir.

Mr. **Fuqua**. Let me expand on the remark about university research. The amount recommended by this committee was much higher than that finally appropriated. Let me get our plug in. [Laughter.]

Mr. **Mares**. It is only fair to you, sir. You gave me free time, too.

Mr. **Fuqua**. What work are you doing in supporting the SFC in some of the environmental activities relating to synthetic fuels?

Mr. **Mares**. We are working very closely in that area. That is probably one of the most important subjects of our interagency agreement.

SFC has just sent out a draft environmental evaluation proposal for comments. We have received it. My understanding is that we actually gave them some help in the course of developing that. We will also comment upon it.

Not only we in fossil energy but we in the Department have been working in providing them as much assistance as they need in the most responsive way we can. I would say, again, I think the working relationship that we have with SFC is very good. That is the sense I get as I talked to the Chairman and the President and several other officers.

If, by any chance, you thought it was not, I would like to be advised because I think it is a very important role for us. I think everyone on the staff believes that.

Mr. **Fuqua**. No, I have heard that you have stated that you have worked very closely with them. Let me commend you for that.

Mr. **Mares**. I think that is one of our responsibilities, and it is a very important responsibility that we are trying to carry out.

Mr. **Fuqua**. Thank you very much, and we appreciate your being here this morning.

Mr. **Mares**. It is a pleasure, sir. Thank you.

Mr. **Fuqua**. Our next witness is Joseph Tribble.

Mr. Tribble, we are pleased to have you here this morning. If you have a prepared statement and you wish to submit it for the record and summarize, I would be happy to accommodate that.

STATEMENT OF JOSEPH TRIBBLE, ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY, DEPARTMENT OF ENERGY, ACCOMPANIED BY DR. ROBERT SAN MARTIN, DEPUTY ASSISTANT SECRETARY FOR RENEWABLE ENERGY; AND DR. MELVIN CHIOGIOJI, OFFICE DIRECTOR, STATE AND LOCAL ASSISTANCE PROGRAMS

Mr. **Tribble**. Thank you, Mr. Chairman.

I would like to introduce my compatriots this morning.

Mr. **Fuqua**. You have two total strangers here.

Mr. **Tribble**. Well, I think they have been around a while, a great deal longer than I have, but there may be some new members of the committee who do not know them.

Mr. **Fuqua**. That is correct.

Mr. **Tribble**. It is my pleasure to introduce, on my left, Dr. Robert San Martin, who is Deputy Assistant Secretary for Renewable Energy; and, on my right, Dr. Melvin Chiogioji, who is the Director of the Office of State and Local Assistance Programs.

I do have a statement which I would like to have included in the record, and I will make some very brief remarks of an overall nature.

We are pleased to be here today to discuss the proposals we have made in the 1984 budget for conservation and renewable energy programs. In accordance with the committee's request, the fiscal year 1984 conservation budget is submitted on the basis of the end-use sectors rather than the more generic categories which characterized the 1983 request.

There are some changes that have taken place since we met at this time last year. The U.S. energy supply situation is more favorable now than it was then. Recent figures indicate that net imports of petroleum into the United States, excluding SPR imports, are now down to 4 million barrels per day.

Considering the deliveries of petroleum to the United States from Mexico, Venezuela, and the North Sea, we as a nation are far less vulnerable to disruptions in the Arab OPEC nations than we were previously. The oversupply of oil is putting pressure on prices, as seen in recent reductions.

Second, there are now more than 300 million barrels of oil in the strategic petroleum reserve.

Third, efforts to improve the efficiency with which we use energy are continuing, and the results of past efforts continue to pay dividends.

These favorable circumstances should in no way minimize the importance of conservation. We are aware of the fact that falling energy prices put additional burden on the Department to highlight the importance of conservation and renewable energy programs.

As a nation, we should not conclude that short-term changes in prices or supply leads to reduced need for conservation and renewable energy.

Generally, a timeframe of from 10 to 15 years is required before research finds it way into widespread use. Conservation and renewable energy research which is done now will be very beneficial in the years to come when the price of energy will surely be higher.

Mr. Chairman, that concludes our general comments, and we would be pleased to attempt to answer your questions.

I would like to add one other thing, and that is that we enjoyed cosponsoring with your staff a workshop recently on building energy performance or building energy efficiency. I think it was a very productive workshop. It brought together people who are experts in their fields. We asked them to give us advice on the things that they thought needed to be done on a nationwide basis, not just for the Federal Government to support but also throughout the private sector.

We have received the rough drafts of the reports from the various working groups, and they have some very good recommendations.

We look forward to additional workshops wherein we will make an effort to determine which of this work may very well be done by the private sector, and to identify more clearly where there are gaps in research so that we can direct our efforts to those areas.

[The prepared statement, plus answers to questions asked of Mr. Tribble, follows:]

PREPARED TESTIMONY OF JOSEPH J. TRIBBLE

Mr. Chairman and members of the Subcommittee, we welcome the opportunity to meet with you again to discuss the proposals we have made in the FY 1984 budget for Conservation and Renewable Energy programs. In accordance with the Committee's request, the FY 1984 conservation budget is submitted on the basis of end-use sectors rather than the more generic categories which characterized the FY 1983 request. We will cover the details of each of these sectors, however, some general comments are appropriate. (First, the U.S. energy - supply situation is even more favorable this year than it was at this time last year). Recent figures indicate that net imports of petroleum into the United States (excluding SPR imports) are now down to 4.0 million barrels per day. Considering the deliveries of petroleum to the United States from Mexico, Venezuela, and the North Sea, we as a Nation are far less vulnerable to disruptions in the Arab OPEC nations than we were previously. The oversupply of oil is putting pressure on prices, as seen in recent reductions. Second, there are now more than 300 million barrels of oil in the strategic petroleum reserve. Third, efforts to improve the efficiency with which energy is used are continuing, and the results of past efforts continue to pay dividends. These favorable circumstances should in no way minimize the importance of conservation. As Secretary Hodel has himself stated in testimony, before this Committee, we are very well aware of the fact that falling energy prices puts an additional burden on the Department to highlight the importance of continuing conservation and renewable energy programs. As a nation, we ought not to conclude that short-term changes in prices or supply leads to reduced need for conservation and renewables. The Federal Government should provide at least sufficient high-level interest and support for conservation and renewable activities to maintain the momentum achieved thus far. Generally, a time-frame of from 10 to 15 years is required before research finds its way into widespread use. Conservation and renewable energy research which is done now will be very beneficial in the years to come, when the price of energy will surely be higher.

RENEWABLE ENERGY

During the past ten years, numerous technical achievements in innovative energy technologies have contributed to the emergence of a renewable energy industry. Research is still necessary, however, to expand the technology base so that industry can continue develop and apply these concepts with its own investment capital. The Federal role in this context is to sponsor long-range, high-risk, high payoff energy research which industry cannot reasonably be expected to exclusively support; and to develop fundamental scientific and engineering knowledge which can provide the basis for new energy developments and the opportunity for increased use of renewable energy.

The budget request submitted to the Subcommittee today represents a continuing commitment to research and development for each technology. These funding proposals were carefully reviewed to ensure that activities to be funded are consistent with the national need. In formulating this request, the Department considered a number of inputs including sources such as the Energy Research Advisory Board (ERAB), Congressional hearings, and discussions with industry representatives.

Four general criteria were used to guide the selection of activities included in this request. First, it should be consistent with the Federal emphasis on long-term, high-risk energy research. Second, the research should add measurably to the technology base. Third, the activity should not duplicate work being performed by the private sector. Finally, the activity should have a high-payoff potential.

SOLAR HEAT

The Solar Heat Technologies program supports R&D activities to provide a technology base which advances the development of thermal materials and which provides a better understanding of thermal sciences.

Previous R&D efforts have provided significant achievements. Experiments with new collector glazing techniques; research on advanced materials; and identification of new technologies to light building interiors show promising cost and performance results. In cooperation with utility partners and the State of California, the Barstow Central Receiver Pilot Plant was completed. This facility is the world's largest solar electric generating plant.

During FY 83, research is being conducted on high temperature materials and concentrators which can significantly improve the performance and reliability of high temperature collectors and receivers. Research will be performed for second generation heliostats, and high temperature storage components. System studies and conceptual designs will be undertaken to determine the feasibility of central receiver thermochemical hydrogen production. The program will also develop, fabricate and test and advanced dish concentrator for generic thermal electric application.

The Solar Heat Technology program request in FY 1984 totals $21.95 million. This request includes $11.75 million for Materials Research, $7.2 million for Central Receiver Technology, and $3.0 million for Heat Transfer Systems Analysis.

In Materials Research, activities will include test and evaluations of materials with improved thermal tolerances, optical properties and heat transfer characteristics. Thermal-related research will involve the testing of materials to determine their ability to withstand the high temperature and thermal cycling encountered in electric power applications and fuel or chemical production. Research will be conducted to develop new low cost, high performance polymer and plastic/metal laminates for low and medium-temperature collectors. Improved thermal conductivity and dependability in heat transfer materials and fluids with the potential to provide substantial improvements in technical performance and reliability will be investigated.

Central Receiver Technology research will include test and evaluation of components and subsystems at the Central Receiver Test Facility. This activity will provide valuable systems information on the integration of advanced heliostats, receivers and associated controls. Research will also be performed to determine materials and assembly integrity to better define the technical risks associated with adapting the central receiver design to industrial process heat applications. Data collection activities will continue at the Barstow facility to validate operating conditions and system reliability for central receiver power.

Heat Transfer Systems Analysis studies will continue to assess thermal and reliability performance. Specific approaches for using solar technology for interior lighting of buildings without adversely affecting cooling loads will be examined and measured in detail. Research to better understand the process and extent of thermal transport in solar buildings will also be conducted.

PHOTOVOLTAIC ENERGY TECHNOLOGY

The purpose of the Photovoltaic Energy Program is to enhance scientific understanding of the technology and provide a basis for the advancement of photovoltaic systems for both dispersed and centralized electric applications. Research is focused on the characterization of photovoltaic materials and concepts which show promise for improved efficiency, stability and cost.

Important advances have already been made in the photovoltaic technologies. For example, amorphous silicon now offers the potential for ultimately lowering photovoltaic cell costs at high volume production rates. During 1982, laboratory efficiencies of 10% were achieved with small area amorphous silicon cells, representing a significant technical advance over the unacceptably low conversion efficiencies previously attained. Through the program, module tests and design algorithms were formulated to stimulate 20 year lifetimes and the performance of state-of-the-art modules was testing using these techniques. The validation of these accelerated life tests and algorithms provides a basis for the testing of flat plate modules to project reliability.

During FY 1983, the effort to develop crystalline silicon PV cells will near completion. This effort will include the operation and evaluation of a facility which has been designed to produce semiconductor grade silicon at less than one-half the cost of other methods. Band structure calculations for copper indium diselenide (CuInSe2) thin film PV cells will be completed this year. Based on this research, a laboratory test cell is expected to show an

efficiency of 12 percent.

For FY 1984, the Department is requesting $32.7 million to continue long range photovoltaic research. This includes $20.5 million for Materials Research,,$5.7 million for Cell Theory and Validation Studies, and $6.5 million of Analysis, Testing, and Reliability Studies.

The Materials Research element will include both Thin-Film Materials and Cell Research, and High Efficiency Materials and Cell Research. Since thin film materials exhibit potential for greatly reducing cell costs, a number of promising thin film materials and deposition techniques will be characterized and investigated. High efficiency research will emphasize the definition and development of materials and cell concepts with the potential for yielding high conversion efficiencies. These activities include conceptual designs for luminescent devices, the laboratory verification of high concentration Fresnel lens modules, and the characterization of materials for multi-layered cells which may potentially achieve efficiencies of 30 to 50 percent. All of these concepts have shown potential for developing more competitive photovoltaic systems.

In the second major area of research, Cell Theory and Validation Studies, analytical models for predicting and interpreting the performance characteristics of new materials for photovoltaic devices and techniques will be developed. The models should result in an increased scientific understanding of the theoretical framework governing the photovoltaic process and should open the door for identification of additional cell concepts. Cell reliability analyses and tests will be conducted on the conceptual designs, and on sample structures of new cells, to determine potential degradation mechanisms. The results will either confirm the validity of initial designs under consideration or suggest alternatives for future research.

Analysis, Testing and Reliability Studies will be conducted on various mechanical and electrical module configurations to better understand failure mechanisms in cells, modules and arrays. The results of these investigations will be used to determine the requirements for long lifetime designs of 20 years or more.

BIOMASS

The focus of the Biomass Energy Research Program is to establish a technology base for feedstock production and energy conversion for various biomass feedstocks.

Significant research has already been achieved in the area of biomass energy. Production-related efforts achieved yields of 60 dry tons per acre per year of microalgae during a high-density outdoor cultivation experiment. In anaerobic digestion, it was observed that rates of methane production could be increased almost twenty-fold by the addition of selected nutrients.

In FY 1983, production-related research will focus on screening, characterizing, and cultivating promising microalgal species for increased oil production, as well as improving yields of short rotation woody species through genetic selection and cloning. In conversion, research is being conducted on the mechanisms of thermochemical reactions, anaerobic digestion, and biological hydrogen production. Research activities will also be conducted in alcohol fuels on integrated system designs, gasification and acid hydrolysis of feedstocks. In-situ methane gas generation research and environmental emissions research for energy from municipal waste will be completed in FY 83.

The FY 1984 budget is $17.3 million. This includes $1.0 million for Production, $12.1 million for Biochemical Conversion, and $4.2 million for Thermochemical Conversion research.

Production R&D will focus on small scale experiments to screen the capability of various microalgae species to produce measurable quantities of petroleum. The data acquired will be used to select or identify the best species for fuel production from aquatics.

Biochemical conversion experiments will be conducted on the characteristics of microorganisms and used to enhance the development of anaerobic digestion, fermentation, and hydrogen conversion processes. These processes offer potential for low-cost liquid and gaseous fuels from renewable resources. Nutritional requirements of anaerobic digesters and pretreatement methods will be examined to determine methods which will increase methane yields, enhance reactor stability, and increase the digestability of the feedstock.

In Thermochemical Conversion, research will involve the determination of the mechanisms, kinetics, and thermodynamics involved in thermochemical conversion processes. This information is a necessary first step in understanding the fundamentals of advanced thermochemical conversion. Activities will include basic research to improve processes for pyrolysis, direct liquefaction, and gasification of biomass feedstocks.

WIND ENERGY TECHNOLOGY

The Wind Energy Technology Program supports research on performance and lifetime characteristics of wind machines for application by the private sector and develops and validates structural and aerodynamic models to increase the overall understanding of wind as and energy resource.

Several successfully concluded activities have contributed to the establishment of a wind technology base. Small wind system research and development performed by the program has resulted in improved machines that help foster the growing small wind industry. In large wind turbine research, initial structural, aerodynamic and environmental tests were conducted at the MOD-2 three unit cluster at Goodnoe Hills in FY 1982. We believe that large scale wind turbines will eventually lower the cost of electricity in utility applications as compared to small or intermediate sized machines.

In FY 1983, the program will continue its aerodynamic and air-foil technology efforts since there is a need for more research in complex flow regimes and high angles of attack that are unique to wind turbines. To alleviate deficiencies in the wind system related aerodynamics data accumulated to date, wind tunnel and smoke flow visualization studies are being continued. Success in these research efforts should allow designers to improve performance 20 to 40 percent at certain wind speeds.

The FY 1984 budget request for Wind Energy Technology is $8.6 million. The three major areas of emphasis include $3.6 million for Aerodynamics Research, $3.5 million for Structural Dynamics Research, an $1.5 million for operation of the Small Wind System Test Center at Rocky Flats.

In Aerodynamics Research, the request provides for the refinement of analytical techniques and the development of an understanding of unsteady aerodynamics, particularly the effects of atmospheric turbulence and turbine wakes. Continued development of analytic models based on analyses of experimental data will also be funded since test results on experimental turbines have shown that performance, wakes, blade stall, and resulting noise are not consistent with current history.

In the Structural Dynamics Research area, further validation of advanced structural models; acquisition of fatique life data from Federal and commercial systems; experimental testing of laminar flow blades and advanced airfoils; and investigation of advanced system configurations will be performed for Darrieus vertical axis systems. Atmospheric fluid dynamics research will emphasize the characteristics of wind turbulence and the resulting effect on turbine aeroelastics. Current ability to predict natural frequencies and structural loads is not adequate to analyze the structural dynamics of advanced wind turbines, particularly new turbines with variable rotor speed.

The third area of emphasis is operation of Rocky Flats Small Wind System Test Center. The request provides for research testing and operation of the Center for fee-paid testing services to small turbine manufacturers, utility companies, universities, and research laboratories.

GEOTHERMAL

The long-range direction of the Geothermal Energy Program is to emphasize activities that will reduce the technical risk associated with exploiting the geothermal resource base. Program activities completed recently include connection of the deep hot dry rock wells at Fenton Hill; the development of improved geothermal drilling systems; and the completion of short term testing of geothermal resource characteristics at various sites.

In FY 1983, construction will begin on the 50 megawatt binary-cycle plant at Heber, California. Support will also be provided to complete the flow testing of geopressured design wells; begin operation of the interim hot dry rock loop; improve techniques to estimate reservoir capacity; and to continue the development of geothermal energy conversion technology.

The FY 1984 budget request is $13.5 million. The budget includes $5 million for Hot Dry Rock research; $4.4 million for Hydrothermal research; $2.6 million for Hard Rock Penetration research; $0.8 million for Magma Ehergy Extraction Research; $0.1 million for Geothermal Technology Transfer; and $0.5 million for Program Direction.

The Hot Dry Rock element will focus on completion of the Phase II thermal loop at Fenton Hill, New Mexico, which will provide a deep-fractured system for heat extraction. The Phase II loop will be operated for an extended period to assess reservoir longevity, operating performance, and environmental effects.

Hydrothermal research efforts will address brine injection technology, reservoir definition, and heat cycle research. Brine injection technology development is required for extending reservoir life and for the disposal of spent brines in an environmentally acceptable manner. Heat cycle research will involve the development of second generation binary cycle systems required for the generation of electricity from low temperature hydrothermal resources.

Hard Rock Penetration research will concentrate on fundamental technical problems related to severe downhole drilling conditions. The program will study the mechanics of rock penetration; borehole mapping; drilling instrumentation and data transmission; and the use of high temperature polymers for fluid loss control.

In FY 1984, the Geothermal Energy Program will take lead responsibility for Magma Energy Extraction research following the successful completion of the energy extraction experiment conducted by the Office of Energy Research. The initial focus of this effort will be to identify the major magma prospects in the U.S. and then to assess the feasibility of exploiting these resources.

In Geothermal Technology Transfer, results of agency-sponsored research and development will be made available to scientists, engineers, industrial users, educators, and other decision makers to foster the utilization of geothermal technology.

GEOTHERMAL RESOURCE DEVELOPMENT FUND

The Geothermal Resource Development Fund (GRDF) was established to accelerate the development and utilization of geothermal energy by promoting competition and encouraging new entrants into the market.

The FY 1984 budget request for the GRDF is $2.1 million. The funds will be used for interest differential payments and program direction.

Let me turn now to conservation research and development.

BUILDINGS SYSTEMS RESEARCH AND DEVELOPMENT

Since FY 1977, and through FY 1983, the Federal Government has spent $120 million on research for improving the energy efficiency of buildings. This research, combined with the base of information available prior to that time, has brought the state-of-the-art to the point where buildings can indeed be built to withstand severe winter conditions without, or with minimal, heating systems. Virtually every facet of energy use in buildings has been studied. The thermal performance of wall and roof systems has been studied in calibrated hot boxes. Fenestration arrangement and design has been carefully studied, as has ventilation, infiltration and energy management control systems. Sophisticated computer programs have been established for determining energy use in buildings. Many whole buildings have been fully instrumented in order to determine the effect on energy requirements of a number of external variables, such as wind, sun and siting. The effects of thermal mass and moisture migration have been studied.

This is not to say that additional work need not be done. Early this year, this Committee and the Department of Energy jointly sponsored, along with other organizations interested in building energy technology, a workshop to evaluate the current status of the body of knowledge relating to energy use in buildings. Our objective was to determine, among other things, what is being done by the private sector and where there are gaps in our knowledge base that need to be filled. To the extent possible, the work which is done in FY 1983 will be directed toward the recommendations from this workshop. FY 1984 activities will be based on these recommendations, to an even greater extent.

INDUSTRIAL PROGRAMS

Of the three major sectors that use the majority of energy, the industrial sector has, by far, the largest incentive to conserve energy. Dollars saved in the reduction of energy consumption are reflected almost directly in profit. For the ten most energy intensive industries, the energy consumed per unit of production in 1980 was 17.7% below the unit energy consumption in 1972. This improvement continued through 1981, when the improvement was 20.8% as compared to 1972. It has been said that industrial research and development is aimed at the short-term only, however, this does not account for such research as that done by the forest products industry, where the payoff is some 30 years away; nor that done in the drug industry, where it may take 10 years to bring a new drug to market; nor that done in the communications industry, where such organizations as the Bell Laboratories have been noted for long-term research. From FY 1977 through FY 1983, the Federal Government will have spent almost a quarter of a billion dollars on industrial energy conservation research and development. The effect of this expenditure has been primarily to accelerate the introduction of innovations which would probably have taken place without Federal participation, although at a later time. This program primarily responds to unsolicited proposals, and of course there are many. An effort is made to select those projects which are generic in nature and will have application to one or more entire industries. The Administration has sought both in FY 1982 and FY 1983 to bring this program to a proper conclusion without additional funding. In anticipation of a request for no funds for FY 1983, most of the projects which were undertaken in FY 1982 were funded to completion. In view of the insistence of the Congress to allocate funds for this program, we have requested $10.6 million for research in FY 1984. With these funds, we would expect to continue work on membrane separation of oxygen for enriching combustion air. We would also go forward with the development of a slagging coal burner which might be used to adapt an oil boiler for burning coal. We would continue the reporting program on industrial energy efficiency and continue R&D on freeze crystallization for improved separation and concentration. This would have application in the food industry and perhaps others.

ENERGY CONVERSION AND UTILIZATION TECHNOLOGIES (ECUT)

The Energy Conversion and Utilization Technologies Program is one which involves technologies cutting across end-use sectors. We have requested $3 million in FY 1984 for this work. With this, we would go forward with the investigation of combustion phenomenon and make an effort to understand "knock" in engines. Another field which deserves some attention is tribology, which is the study of friction and its elimination or minimization. The use of solid lubricants will be required in many high temperature applications, such as the use of ceramics in engines.

Mr. Chairman, that concludes my statement. We will be glad to answer any questions you may have.

PREHEARING QUESTIONS
FROM
HONORABLE DON FUQUA
RELATING TO THE
MARCH 8, 1983 HEARING
BEFORE THE
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
HOUSE OF REPRESENTATIVES
WITNESS: JOSEPH TRIBBLE
ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY

Conservation - General

Question 1. The ERAB conservation R&D panel report stated that, "disruption, lack of certainty about budgets, changes in personnel and inability to plan for budgets may reasonably be expected to have all combined to make an effective conservation R&D program extremely difficult to administer."

Mr. Hodel, at his posture hearing before the full Committee, agreed with that statement. What is being done to resolve that situation?

Answer: With the passage of an FY 1983 Conservation R&D budget and the Department's submission of a higher FY 1984 proposed budget, we believe that program uncertainties will be reduced. Meaningful conservation R&D programs are being planned and conducted in accordance with Congressional guidance. The disruption caused by the reorganization and subsequent Reduction-in-Force (RIF) in September 1981 has subsided, with the staff now in place performing at highly productive levels on programs that will continue to have stability for the foreseeable future.

Conservation - General

Question 2. The ERAB conservation report also states that, "According to DOE, the (Conservation) division has lost a large number of qualified persons, particularly at the senior management level. Experience, knowledge, and program continuity have been lost."

What is being done to remedy that situation and to provide motivation for experienced senior program managers to remain in the program?.

Answer: We have not lost a large number of persons at the senior management level in our Conservation programs. In the past 17 months, we have only lost 9 senior management level staff out of a total of 65 program managers. The Conservation organizational structure has remained relatively constant, creating stability and increasing morale. Critical vacancies have been identified and approved for appropriate personnel action where justified. The approved funding for FY 1983 and the proposed FY 1984 budget has demonstrated the Administration's intention to maintain conservation programs, also leading to improved morale.

Conservation - General

Question 3. The ERAB conservation R&D report recommends that "The Federal Government . . . undertake R&D directed at reducing its own energy consumption. The Department of Energy should direct the non-Defense R&D . . ." What is the Department doing to implement this recommendation?

Answer: R&D conducted by DOE in building systems, transportation, and industrial processes is aimed at reducing energy use in both the private and public sectors. Most of this work does have application to Federal operations and buildings. Information on techniques and technologies applicable to Federal programs and activities is disseminated routinely to Federal energy managers through a number of channels. Interested Federal agencies are included on distribution lists for publications and reports, as well as manuals developed for specialized applications. Other Federal agencies participate in workshops and conferences aimed at providing the latest information on energy conservation measures. The Department's Federal Energy Management Program provides an interagency network to identify and address common problems and innovative approaches. Thus, the Department does actively pursue the implementation of the ERAB recommendation through its research programs and through follow-on efforts to disseminate the results of this research to other Federal agencies.

Conservation - General

Question 4. Please provide for the record the dollar value of all procurements that have been signed by the Office of Conservation and Renewable Energy in FY 1983, as of March 1, 1983, for each conservation program.

Answer: The total budget authority for all conservation procurements signed off by the Office of Conservation and Renewable Energy for the period October 1, 1982, through February 28, 1983, follows (dollars in thousands):

Building and Community Systems	$ 10,899
Transportation	50,810
Industry	11,086
Energy Conversion Utilization	5,269
Electric Energy Systems	6,670
Energy Storage Systems	16,049
TOTAL	$100,783

Building Energy Research

Question 1. Why is there no funding requested for indoor air quality research in the DOE FY 1984 budget request?

The Building Energy Research Workshop Panel I.c. lists "contaminant sources and characterization," "observed concentrations," "exposure studies," "health effects issues," and "contaminant control strategies" as "important to critical" and needing $5-10 million apiece.

Since this is basic or applied research which industry is only funding in a limited way, why is no DOE research planned in this area in FY 1984? What activities are being terminated as a result of this budget cut?

Answer: The Department agrees that the indoor quality research areas listed by the workshop panel are important. DOE research has helped to define potential air quality problems associated with very tight (low-infiltration) buildings, with unvented combustion heating devices, and with urea-formaldehyde foam insulation. Our research has also led to the development of some inexpensive portable instrumentation for measuring contaminant levels in buildings. By the end of FY 1983, DOE will have completed the research necessary to identify and quantify many of the sources of the problem. DOE has assumed most of the financial responsibilities in this area, although the impacts are more on health and quality of life than on energy issues. Leveraging FY 1983 funds with private sector organizations (EPRI, GRI, etc.) will provide data base enhancement into FY 1984 and FY 1985. Available funds will be sufficient to conduct an appropriate level of energy-related research in this area. It is up to other Federal agencies (EPA, CSPS, etc.) to further quantify contaminants and other indoor air quality issues appropriate for their areas of responsibility, and the private sector has the responsibility to apply the results of the research to materials and equipment production and utilization.

In FY 1983 and FY 1984, using prior year funds, DOE work will be completed on a field validation of CO passive monitors, a field study of formaldehyde control, a study of energy recovery for exhaust air (co-funded with BPA), radon control efforts, radon transport through crawl spaces, ventilation efficiency in large buildings, and a lab study on air washing for formaldehyde control.

As an outgrowth of radon health effects studies related to uranium mining and milling, a modest research program is being maintained elsewhere in DOE to investigate radon migration pathways into structures, to determine radon daughter particulate size distributions and plate-out rates, and to examine environmental influences on radon daughter concentrations. Also, an effort to assess the significance of these parameters with respect to potential health effects is continuing.

Building Energy Research

Question 2. Why is no funding requested for basic and applied research in infiltration and ventilation? These two research areas were rated as important by the Building Energy Research Workshop and have been historically part of the DOE Building Systems program. What activities are being terminated as a result of this budget cut?

Answer: DOE research in infiltration and ventilation has progressed to the stage where private sector enterprises can proceed, based on market demand for products and services in these areas. Our research in infiltration has provided a good understanding of infiltration in single-family residences. Very inexpensive infiltration monitoring devices (tracer gas emitters and detectors) have been developed and are available for private enterprise production and marketing. Work in evaluating air-to-air heat exchangers has progressed to the point where private industry can use the results to help provide more effective devices.

The Department feels that continuation of research in these areas for application to commercial buildings and multiple-family residential buildings should be the responsibility of the private sector. In fact, the major improvements in technology have occurred in the private sector, with minimal Government involvement. DOE's contribution in the areas of natural ventilation guideline development, attic ventilation design guideline development, large building infiltration measurements and modeling, and instrumentation development for determining air leakage of buildings will be concluded with FY 1983 funding.

Building Energy Research

Question 3. What is the impact of funding reduction in Building Systems on the budget and personnel levels for FY 1984 for the Lawrence Berkeley Laboratory Energy Efficient Buildings Program?

Answer: The Department request for FY 1984 in this area represents a reduction of $2.9 million from the FY 1983 appropriations. This reduction would require the reassignment of about 45 persons (combined number of laboratory and subcontractor employees) employed by LBL for Building Systems work (out of a total of 75-80).

Question 4. What is DOE/CE doing to persuade the DOE Office of Environmental Research, the Environmental Protection Agency, and the Department of Health and Human Services to fund research on indoor air quality, especially in the areas of concentrations, exposures and health effects?

Answer: For several years, the Department has worked toward coordinating its building ventilation and indoor air quality research with related efforts by other offices of DOE and with other Federal agencies. A key mechanism in this effort has been the Interagency Coordinating Working Group with participation by DOE, DOD, HUD, EPA, CPSC, HHS and DOC (NBS). Building Systems personnel continue to maintain communications with appropriate personnel in these other agencies, to compare notes on programs and to suggest strategies to optimize the effective use of research resources.

Building Energy Research

Question 5. Panel II.a. and II.b. at the Building Energy Research Workshop characterized performance monitoring and evaluation, and performance prediction, as critical needs. Yet, the only planned activity in this area listed in the DOE FY 1984 budget request is $1.4 million for thermal performance monitoring, directed primarily at active solar systems. Why is so little funding requested for these important activities?

Answer: DOE has invested significant sums in performance monitoring and evaluation and in performance prediction over the years. In some, years, fully half of the active and passive budgets and large portions of our conservation budget have been invested in an effort to understand building performance. Instruments have been designed, calibrated and tested; buildings have been instrumented and monitored, with large numbers of data points accumulated. Much of this data is still being analyzed. Sophisticated model codes have been developed, validated and expanded. There is significant activity in this area also being conducted by the private sector. Controls companies have extensive R&D efforts to develop algorithms, strategies and sophisticated codes. Likewise, major equipment manufacturers and some academic and professional societies and practitioners in architecture and engineering have also made significant contributions. Needless to say, with this concentrated effort over several years, some conclusions have been reached, and we have much improved our understanding of building energy performance. We intend to maintain at least one major modeling code, adding to this as scientific advances occur.

Performance monitoring and evaluation, and prediction, will continue as one element of our materials, components, and related research. We also plan to work with industry in FY 1983 and FY 1984 to transfer the technology developed and to catalyze the willingness and ability of industry to use the results of DOE-funded research in the development of further performance monitoring and prediction tools tailored to the varied needs of the numerous segments of the buildings industry. We feel the FY 1984 budget is fully adequate in light of the important technical advances that have been made and the extensive and continuing provate sector efforts in this area.

Question 6. Heat transfer research for passive solar has been cut from $3.5 million in FY 1982, to $520 thousand in FY 1983, to $200 thousand in FY 1984. What is the rationale for this reduction in a basic research program? What activities are being eliminated as a result of this budget cut?

Answer: Previous passive solar natural convection and heat transfer research resulted in better techniques for predicting and understanding these phenomena in buildings. Private industry should now have adequate information to modify their design criteria and thus reflect current knowledge in their practice.

As a result of private industry reflecting current research in their design practice, further analystical research and bench-scale experiments are unnecessary and will be replaced by fundamental studies of advanced heat transfer concepts.

In addition to the $200 thousand mentioned, $650 thousand is included in the FY 1984 request for heat transfer materials and fluids, some of which will be applicable to passive solar. Moreover, DOE is requesting increased funding for aperture materials research that DOE believes to be very important for passive solar.

Building Energy Research

Question 7. What steps is DOE/CE taking to prepare a supplemental FY 1984 budget request to take into account the research recommendations made at the Building Energy Research Workshop?

Answer: The Department is reviewing and considering in detail the research recommendations made at the Building Energy Research Workshop. This information will be used, where appropriate, to focus the R&D program proposed for FY 1984 to ensure that it fulfills the appropriate Federal Government contribution to meeting the National needs identified at the Workshop. At this time, it does not appear that a supplemental FY 1984 budget request will be necessary. It should be emphaized that the research agenda addressed at the Workshop identified national needs in the research area, but that many of these needs can and should be met by the private sector.

Building Energy Research

Question 8. Lighting research and development was funded at $2 million in FY 1982, but is cut to $1 million in the FY 1984 request. Why? What activities are being terminated or reduced and what performers will be affected by this cut?

Answer: The lighting R&D budget is being reduced from $2 million in FY 1982 to $1 million in FY 1984 for a number of reasons. Research projects believed to have the highest potential for contributing to advances in lamp technology and systems integration have been selected to continue in FY 1984. Lamp technology activities which will conclude in FY 1983 that will not be continued into FY 1984 include work on the lamp-gas isotope-separation process, novel gas mixtures, an electrodeless high-frequency flourescent lamp, and an electrodeless high-intensity discharge lamp. DOE's contribution to system integration work will be concluded (lighting controls and advanced lighting design manuals). In the lighting impacts area, DOE's research will also be concluded on models relating visibility to performance. Visual display terminal visibility and the quantitative analysis of health effects of lighting will be deferred to the judgment of agencies with principle missions in the areas of health-related research.

Performers affected by this budget reduction would be GTE Lighting Products, Quontatec Westinghouse, General Electric, University of California School of Optometry.

Building Energy Research

Question 9.	Heat pumps and refrigeration systems received a combined budget of $6.6 million in FY 1982, but have been reduced to $2.75 million in the FY 1984 request. Please explain the reasons for this reduction. What activities are being terminated?
Answer:	Major reduction from FY 1982 in heat pumps and refrigeration systems consist of $1.3 million in thermally-activated heat pumps, $1 million in heat exchangers and $1.3 million in Rankine systems research. These reductions are being made in recognition of the progress made by industry, and weighing the marginal potential for advances in this work. We intend to pursue those long-range, high-risk activities having the highest potential for success in energy savings over the long term while dropping those activities that are capable of being pursued over time by industry and activities of less technical promise. In thermally-activated heat pumps, the funding level will allow priority work to proceed on both heat-engine-driven and absorption heat pumps. Work concluded in this area includes generic research in Stirling engine heat pumps thermodynamics and controls and in internal combustion engine heat pumps. In the heat exchanger generic research area, work continues in ground-coupled heat pumps. Work concluded consists of frosting and defrosting losses for air-source heat pumps. All work in the Rankine systems research area will be concluded in FY 1983. This includes research in dynamic losses of heat pumps, non-azeotropic refrigerant mixtures, computer simulation and optimization methods, variable-capacity concepts, zone-control concepts, and in-use heat pump performance.

Building Energy Research

Question 10. What is DOE/CE doing to address the research topics in the areas of behavioral and institutional barriers that were identified by Panel 111 of the Building Energy Research Workshop, and by the ERAB conservation R&D report?

Answer: The workshop and its draft report identified many areas where additional information would be helpful to the private sector in making decisions about implementing new energy-efficient procedures or products. The potential for leadership in removing or reducing some of the institutional barriers identified by the workshop challenges not only DOE, but also other Federal agencies, professional societies, financial institutions, products approval laboratories, building code organizations and others to make it easier and less time-consuming to implement new strategies and to introduce new products that will enhance energy conservation and renewable energy use in buildings technologies. We are continuing to study the input from the workshop, and look forward to future opportunities to work with this committee and the other co-sponsors to understand what other research organizations are doing and what appropriate DOE responsibilities might be. In the specific area of institutional barriers, DOE is continuing to work with the private sector to overcome such barriers, such as the efforts to develop a home energy rating system which would scale the annual energy use per unit area per degree day in such a way that lenders as well as homeowners could compare the energy valua of residential properties.

Building Energy Research

Question 11.	The ERAB conservation R&D panel found that, "the levels of privately sponsored R&D in the building sector is small," but the "potential for energy savings and net economic benefits is enormous." Given this finding, will DOE modify its position (July 22, 1982) that the buildings trade associations should fund most building energy research?
Answer:	Building energy use has decreased by 15 percent per household since 1972. We are impressed more and more each day as we learn of the significant buildings energy R&D being conducted by EPRI, GRI, NAHB, AIA, ASHRAE and several Federal and State agencies, and the hundreds of materials and components companies and architectural and engineering firms. TVA and BPA are both actively pursuing buildings R&D programs. The total investment in buildings R&D by the public and private sectors is indeed impressive. DOE has the opportunity to monitor this vast R&D effort and to select those items that are not being adequately addressed which, if conducted, would significantly contribute to the national needs in buildings energy R&D. We recognize the budgetary limitation of buildings trade associations as corporate entities, but also appreciate the fact that work carried out by these associations corporately only represents the tip of the iceberg compared to that carried out by member companies. Not only do we feel that the bulk of the R&D should be funded by these organizations and their members, but we conclude that this is no different than the way such R&D has been funded in the past.

Industrial Energy Conservation

Question 1. The Energy Analysis and Diagnostic Centers have been consistently shown to return to the federal government as much as 100 percent on its investment. Why are no funds requested for this highly cost-effective program which is consistent with the DOE position of supporting technology transfer and information dissemination?

Answer: The Energy Analysis and Diagnostic Centers (EADC's) provide assistance to small and medium-sized firms by conducting energy audits in their plants and advising them on how to save energy. Sincethe private sector has many firms offering this service, it is not considered prudent to spend taxpayer dollars for this program, especially in view of current deficits.

Question 2. The OTA study of cogeneration finds that, "R&D efforts should concentrate on demonstrating high E/S co-generators that can burn solid fuels cleanly--". The ERAB Conservation R&D Panel also recommends "research on advanced topping cycles (coal-fired Brayton systems, diesels, thermionic burners)". Since these activities were, in fact, included in the OIP cogeneration subprogram, why are no funds requested for this subprogram in the FY 1984 budget?

Answer: Cogeneration activities were provided in the FY 1983 appropriation. This funding will provide adequate resources to ensure completion of meaningful milestones and allow the private sector to determine the economic attractiveness of these technologies which are well within their own capabilities to develop if they choose to do so.

Industrial Energy Conservation

Question 3. According to the briefing charts provided for the Committee on January 31, 1983, the industrial process efficiency subprogram was funding research in the following areas in FY 1983 which are not included in the FY 1984 budget request:

Catalyst Research,
Coatings Research,
Black Liquor Characterization,
Energy Efficient Farming,
Oxygen Production,
High Temperature Materials Processing, and
Advanced Electrode R&D

Please explain why each of these activities is being discontinued, especially in light of the ERAB Conservation R&D Report which recommends continued funding for most of these activities?

What research efforts would be pursued under each activity area if funding were provided in the FY 1984 budget?

Answer: Each of the activities are either being completed or carried to a reasonable milestone using FY 1983 or prior year budget authority, and therefore are not being discontinued in the sense of being terminated without a resulting benefit.

If FY 1984 funding were provided, research would continue on the highest priority areas of uncertainty. Since the bulk of these funds would be used to respond to unsolicited proposals, specific activities cannot be identified at this time.

Energy Conversion and Utilization Technologies

Question 1. This program supports basic and applied research which is entirely consistent with the Administration's guidelines. It was scheduled, under the Carter Administration, to grow to $25 million a year. Yet the FY 1984 DOE budget request calls for a cut of 67 percent, from $9 million to $3 million. Why?

What activities will not be funded as a result of this cut?

Answer: The Administration guidelines place emphasis on basic and applied, long term, high risk research. The end-use sector programs in Conservation have reoriented their projects away from expensive demonstrations, outreach and system hardware development, which were emphasized in the past, and to a focus on basic and applied research. This reorientation has resulted in reduced requirements for a continuing ECUT program. No new funds are being requested for materials research. However, materials research will continue into 1984 with FY 1983 funds. Ceramics research will continue in the Transportation program. Diesel engine combustion research will not be continued since industry effort is well underway in connection with particulate R&D.

Question 2. Why have heat exchangers and materials R&D been dropped from the FY 1984 request for ECUT, in light of the ERAB conservation R&D panel recommendation to continue these activities?

Answer: The heat exchanger work will continue into 1984 with FY 1983 funds. This work has reached the point where sufficient test data on flow-induced vibration have been collected to permit evaluation in FY 1984 to verify appropriate mathematical models developed earlier in the program. As noted in question 1 above, some materials work will continue into FY 1984. Ceramics research funds have been requested in the Transportation budget requests.

Energy Conversion and Utilization Technologies

Question 3. Why are no funds requested for diesel engine R&D in the combustion subprogram of ECUT?

Answer: We recognize that diesel combustion work is now well underway in industry with emphasis on control of particulates. In 1981 when this DOE work on diesels began, there was little, if any, industry research planned; that is now not the case. Continued DOE activities in this area would be duplicative; therefore, there is no request for funds in FY 1984.

Inventors Program

Question 1. The Oak Ridge evaluation of the Inventors Program found that "ERIP is supporting inventions at a point in the innovation process where the private sector is not functioning" and that "ERIP is not only contributing to the stimulation of innovation in the long run but also . . . funding projects that are most likely to succeed." Finally, the evaluation also found that "ERIP is generating a great deal of private sector activity with small investments."

Given the obvious success of this program, and lack of duplication with the private sector, why are no funds provided for it in the FY 1984 budget request?

Answer: No funds are requested for the inventors program in the FY 1984 budget request because it is considered that recent changes in the tax laws and heightened interest in high technology business have improved the availability of financing for inventors through venture capital and R&D limited partnerships to the point where the program is no longer needed. Many States have also established programs to assist or stimulate the start-up of technology-based businesses.

Inventors Program

Question 2.	To what extent does the new Small Business Innovation Research program in OER address the same audience and the same needs as the Energy-Related Inventors Program?
Answer:	The Small Business Innovation Research (SBIR) Program, addresses, to a limited extent, a portion of the same audience and needs as the Energy-Related Inventions Program in that it supports research by small businesses in selected topic areas. However, this is a research program which requires the submission of research proposals, on specific topics of generally a more basic research nature. Thus, the inventors, as a rule, would have to be associated with such a research organization.

Solar - General

Question 1: The ERAB Solar R&D report states that,

> Continuity in Federal actions is essential to solar R&D, as it is to all R&D. Rapid changes and discontinuities in Federal policy and program direction over the last five years have been disruptive to orderly technical progress and have caused uncertainties and unanticipated cuts in the private sector.

Why, given the above, is DOE proposing to cut the solar budget by 60 percent once again?

Answer: The proposed renewable energy budget represents a firm commitment to sound technical progress in each of the technologies for which funding has been requested. The basic premise of Federal support for solar R&D under this Administration, i.e., long term, high-risk, high payoff, remains unchanged. Although the budget reflects a definite shift in priority from prior Administrations, the major impacts have been felt in non-R&D areas (commercialization, etc.) no longer considered an appropriate Federal function. While the FY 1984 budget request for solar R&D is below the Congressional appropriation level in FY 1983, it does represent an increase of approximately 25% over the FY 1983 Departmental request. Requested funding levels recognize the completion or near-completion of many projects and demonstration activities, the completion of the Federal role in specific programs, or the merger of various research activities into one program area to eliminate duplicative or overlapping R&D activities. While these factors have contributed to an overall reduction in the budget request, the request for FY 1984 activities consistent with long-term, high-risk R&D objectives has in many areas been strengthened. In addition, many near-term technology development activities are being funded by private industry. The DOE program does not wish to interfere or supplant funds targeted for investment by the private sector.

SOLAR - GENERAL

Question 2: Mr. Fuqua and Mr. Lujan are introducing a bill to increase the business tax credits for solar, wind, geothermal and ocean thermal property to 25 percent and to extend them to December 31, 1990.

What is the Department of Energy's best estimate of the impact of such a bill on the ultimate market penetration of advanced renewable energy technologies such as photovoltaics, wind, solar thermal, geothermal and OTEC?

Does DOE support extension of the solar business tax credits to 1990?

Does it support their increase to 25 percent?

Answer: Existing business tax credits have been beneficial to renewable energy technologies. Although the DOE does not conduct or sponsor market studies or market penetration analyses, we do maintain a dialogue with industry representatives to obtain feedback on important renewable energy technology issues. Through the exchange of information and opinions at recent conferences and program reviews, it is believed that the impact of an extension of the tax credits on the ultimate market penetration level will be dependent on factors such as the performance and technical readiness of renewable energy systems; the cost of capital; the cost and availability of conventional energy supplies; and general economic conditions.

DOE does support an extension of the tax credits in principle. In concurrence with ERAB recommendations, if the credits are extended to 1990, the benefits of a phasedown strategy after 1986 should be carefully considered for particular solar technologies. DOE has not developed a position on the proposed increase of the credits to 25 percent.

Comprehensive tax policy issues are the responsibility of the Department of Treasury. At this point, no administration position on this bill has been established. DOE will provide Treasury with whatever data or insights we have regarding proposed energy tax credits to assist them in the formulation of a position on this proposal.

Solar - General

Q 3. Please provide for the record the dollar value of all procurements that have been signed off by the Office of Conservation and Renewable Energy as of March 1, 1983, for each solar energy program.

A 3. The following summarizes DOE Assistant Secretary for Conservation and Renewable Energy FY 1983 funding authorizations for solar energy research and development as of March 1, 1983.

FY 1983 ASSISTANT SECRETARY FUNDING AUTHORIZATIONS - 3/01/83

SOLAR PROGRAM	**($ in 1000s)**
Active Solar Heating & Cooling	**$ 3,343**
Passive Solar Heating & Cooling	**2,123**
Photovoltaics	**14,261**
Solar Thermal	**9,900**
Biomass	**423**
Alcohol Fuels R&D	**4,183**
Wind	**5,322**
Ocean	**3,596**
Solar International	**9,500**
Solar Information	**2,104**
Solar Program Support	**272**
Solar Reserve Account	**428**
TOTAL SOLAR ENERGY R&D	**$ 55,455**

Photovoltaics

Question 1: A report prepared by Strategies Unlimited for the Solar Energy Industries Association contained the following recommendation from the photovoltaic industry:

> Technology development activities merit expansion within the DOE program. These activities frequently entail high risk for industry, yet might potentially yield large rewards for the technology.

Please justify your decision to terminate all PV technology development activities in the FY 1984 budget request in light of the above industry recommendation.

Answer: The FY 1984 budget request includes some funds to continue technology development activities that are generic in nature, and truly fit the Department's criteria of long-term, high risk, high-payoff R&D. For example, an element of the FY 1984 budget request includes $6.5M for "Analysis, Testing and Reliability Studies." This includes the collection and analysis of data from cells and modules of differing configurations, the development and implementation of accelerated lifetime testing methods for modules and the environmental testing of new generations of modules. The data collected and analyzed from these activities will provide feedback for the design of modules with improved performance and reliability.

Items eliminated in the FY 1984 photovoltaics budget request are principally technology development activities that are of lower technical priority and are related to concepts where R&D has advanced to the stage where the private sector can pursue further development on its own if the economics appear promising.

Photovoltaics

Question 2: The ERAB Solar R&D report recommended support for the following activities in the DOE photovoltaics program:

a. "Development of promising techniques that involve the integration of individual process steps..."

b. "Development of advanced processing equipment..."

c. "Cost reduction techniques for single crystal silicon materials.."

d. "Concentrator systems R&D."

e. "Advanced silicon sheet R&D."

No reference is made to any of the above activities in the FY 1984 budget request. Why is this recommendation of the ERAB R&D panel being ignored?

Answer: The Photovoltaics Program is actually highly consistent with the ERAB panel recommendations. For example, the silicon materials research effort will continue to a logical completion, that is, until the individual process steps developed under the Program have been successfully integrated (12/84). There will also be research to understand thin film deposition techniques expected to be used eventually by the private sector in the development of advanced processing equipment. In addition, the single crystal silicon materials development effort is nearing a logical completion which will result in the establishment and transfer to industry of process steps capable of reducing the cost of high purity silicon to less than $20/kg. In the concentrator systems R&D area, first generation technology is currently being demonstrated; second generation systems are under test, and the development of third generation designs is underway. This effort, however, must progress at a pace that is consistent with the collection, evaluation, and application of first and second generation test data. The development of advanced silicon ribbon technologies is also continuing. In FY 1984, the most promising of the four ribbon technologies under development will be selected for continued research, and the critical issues of stress and strain will be addressed. This effort has been most successful to date, and has advanced to the stage where manufacturers can privately develop in-house processing equipment which best suits their particular application and needs.

Photovoltaics

Question 3: Roger Little of Spire Corp. testified to the Subcommittee on Energy Development and Applications of July 29, 1982 that,

> Reduction in the R&D efforts associated with the Technology Development area will severely hurt today's industry and make it much less competitive on an international front... It is this area of problem solving and small companies which is most in jeopardy due to Federal Government budget cutbacks.

Do you have any evidence that contradicts Mr. Little's statement?

Can you in any way demonstrate that cutbacks on federal funding for PV technology development will not have the effects on industry, its international competitiveness and on small business in particular that Mr. Little predicts?

Answer: The U. S. industry currently dominates worldwide flat plate silicon sales, selling more than all foreign competitors combined. An area that does require continuing attention is the development of thin film photovoltaic systems. A specific group of foreign manufacturers has received a large amount of attention in the press largely as a result of their sales of specialty consumer products such as photovoltaic radios and watches. These manufacturers to date have not had success in sales in major power markets. The DOE photovoltaic program is addressing this concern by placing the highest emphasis on the development of thin film technologies which have the potential for substantial impact in major power markets, where the bulk of sales is likely to occur. The DOE program is establishing a firm technology base that industry can build on to maintain its competitiveness.

The Department continues to value the participation of small business in the photovoltaic program and expects that small businesses will continue to maintain a 15-25 percent share of funds contracted to private industry. In addition, the Department has included photovoltaics as a research topic within the Small Business Innovation Research (SBIR) program managed by the Office of Energy Research.

Question 4: In a survey conducted by the Subcommittee on Energy Development and Applications, 90 percent of the respondents favored further federal funding for crystalline silicon PV research and development. In light of this finding, would DOE be willing to reconsider its position against funding this kind of research?

Answer: The FY 1984 budget request emphasizes funding for the highest priority R&D which offers potential for high payoff in the long term. Budget requests have been consistent in this regard from year to year. Specific areas of emphasis, however, are continually evolving as technologies are developed and evaluated.

The referenced survey was conducted during a prior fiscal year, when the status of various technologies and the international market were different from what is anticipated in the coming years. The FY 1984 request reflects the R&D needs of photovoltaics in the future.

Just last month (February 1983), the Photovoltaics Annual Program Review was conducted with substantial industry participation and feedback. The FY 1984 request reflects the concerns stated by industry at that meeting.

Photovoltaics

Question 5:	The Strategies Unlimited report cited above also recommended that,

> The Federal Government should ensure that each Federal agency, through its normal procurement processes, utilizes photovoltaic energy systems wherever cost effective.

What is DOE doing, as the lead Federal agency in the energy field, to make sure that the above recommendation is being carried out in its own practices and throughout the Federal Government?

Answer: Several months ago, DOE initiated an information transfer program with the specific objective of expanding the use of photovoltaics within the Federal Government. The Program is an extension of the Federal Photovoltaic Utilization Program (FPUP), which will result in over 2700 operational systems in 26 Federal agencies. The program will continue through FY 1984.

Thus far, the information transfer program has accomplished the following:

- Individual meetings with DOD (OSD, Army, Navy, Air Force), FAA, Forest Service and Park Service staffs to encourage the procurement of PV systems.
- FPUP managers/systems suppliers joint meeting to share experiences and future plans. Twenty-six different organizations participated in the meeting.

Future plans include visits to other Federal agencies and the development of a PV Handbook which will contain "lessons learned" during the conduct of FPUP. The Handbook will be made available to Federal agencies and others to assist them in the procurement of future PV systems.

Seven Federal agencies have already committed to procure PV systems over the next several years utilizing their own funding.

Solar Thermal

Question 1: According to Solar Thermal Energy Association testimony to the Subcommittee on Energy Development and Applications in March 1982, $6.8 million will be required in FY 1984 to support the development and testing of advanced receivers, steam generators, and storage systems. Why is no funding requested for these needed advanced component development activities?

Answer: The Department has supported a number of activities related to the development and testing of solar thermal receivers, steam generators, and storage systems. The Department proposes to continue to fund research in FY 1984 in the areas of the greatest remaining technical uncertainty including many of those recommended by the Solar Energy Industries Association in 1982.

In FY 1984, the Department proposes to continue the test and evaluation of the Barstow pilot plant ($4.0 million); to operate the Central Receiver Test Facility ($2.0 million) for evaluation of advanced components, particularly with regard to their integrated operations; and to design, fabricate, and test advanced components and subsystems suitable for generic application in mid-sized industrial process heat plants ($1.2 million).

Additionally, a portion of the materials research proposed within the generic Solar Heat budget category will contribute to further development of this technology. This combination of continued materials research and component development and evaluation projects proposed for FY 1984 funding has taken this technology far enough along the technology development path that further equipment development can be pursued by the private sector in future years in response to market forces.

Solar Thermal

Question 2: If no funds are provided for detailed design of one or more solar thermal repowering plants, are any of the conceptual designs currently being funded by DOE likely to be built in the near future, according to your best estimate?

Answer: Four of the repowering designs and at least two of the Southern California Edison Solar 100 designs are under active consideration for private financing. The details of on-going discussions are not available to us; therefore, DOE has no basis for predicting the likelihood of these projects being built. Decision will depend on a number of factors, most importantly, economics of the projects.

Nevertheless, DOE feels confident that the technology base already developed and being expanded in FY 1984 has considerably reduced the technical uncertainties associated with solar thermal repowering. The private sector can pursue this when economics appear favorable.

Solar Thermal

Question 3: The ERAB Solar R&D report recommended that,

> DOE should provide a redirection of emphasis to the parabolic dish program because of its potentially higher efficiencies and lower costs.

Despite this recommendation, no funds are provided in the DOE FY 1984 request for parabolic dish technology development. Why?

Why does DOE continue to ignore explicit recommendations such as this one from its own advisory board?

Answer: The FY 1984 budget contains a request for funds to maintain a materials research program, both to develop high performance, light weight concentrators and to develop high temperature high flux receiver materials. This effort strongly supports long-term parabolic dish development. Short-term dish activities, including small community Experiments I and II (which are currently funded), will be completed without FY 1984 funds and will result in technically viable first generation systems. This proof of system concept will conclude the systems development aspect of the dish program, leaving remaining systems work to the private sector.

In preparing its total FY 1984 R&D budget, the Department considered a number of inputs including sources such as ERAB, Congressional hearings and informal discussions with industry representatives. In this particular case, we did not take ERAB's advice for the reasons mentioned above.

Solar Thermal

Question 4: Do you have any evidence that the private sector will pick up the parabolic dish development work you are dropping?

Do you have any evidence that this technology can be brought to the marketplace without further federal support?

Answer: It is difficult to predict private sector response to technological opportunities such as are presented by parabolic dish research completed to date, although a body of knowledge does exist which will allow industry to proceed with development. While dish technology products are available for thermal and electric applications, energy costs, when compared with the price of conventional energy have not encouraged substantial sales of this technology to date.

Q 5. Why are no funds requested in the FY 1984 budget for basic and applied research in solar thermal fuels and chemicals production?

A 5. Fuels research activities have become part of the overall materials research program. Since the fuels and chemicals program emphasis is aimed primarily at the production of hydrogen, materials and thermo/chemical processes capable of operating at higher temperatures over sustained periods will be required for efficient fuel production systems. A major thrust in the materials research program is to identify, characterize and test materials with these required attributes.

Biomass

Question 1: The OTA Report on "Energy from Biological Processes" (July 1980) recommended that the following R&D activities be carried out with respect to crop production: "wood harvesting," "surveys (to determine the resource base)," "crop switching," and "crop development."

Why has DOE chosen to eliminate short rotation woody crops, herbaceous crops and wood harvesting from its biomass program?

Answer: The forest products industry has the capability to pursue this work. Currently wood is more valuable as a raw material for pulp, paper and solid wood products, so tree plantations strictly for energy purposes are uneconomic. However, if conditions change, the forest products industry will be able to undertake short rotation woody crops production on its own in response to market forces.

Current research activities in the development of herbaceous crops will be completed and will provide the technology base needed by industry to proceed with development of these crops in accordance with market forces.

While the biomass energy program is designed to support long-term, high-risk research, harvesting is a near-term technology. The U.S. Forest Service has funded the development of harvesting technology for many years. The forest products industry is capable of completing the development and implementation of harvesting technology and has pursued development of a number of types of harvesting equipment on its own.

Biomass

Q 2. The ERAB Solar R&D report recommended that DOE:

Investigate the genetics of crop and forest plants for increased productivity.

Investigate new plant species to determine their potential for biomass energy production.

Develop new collecting and harvesting technologies for forest and agricultural and lignocellulosic materials.

What activities will be carried out in those areas in the FY 1984 budget request?

If none, why not?

A 2. The agricultural and forest products industries have demonstrated the capability to pursue work related to the investigation of genetics of crop and forest plants and collecting and harvesting technologies for forest and agricultural and lignocellulosic materials. As a result of this private-sector investment in these near-term R&D activities, FY 1984 biomass production-related activities will emphasize high-risk research in areas that carry the possibility for development of high-payoff technologies for the production of oil and other energy intensive products. Specifically, the program will conduct investigations related to new aquatic plant species and conduct genetics research for the most promising aquatic species.

Biomass

Q 3. According to the ERAB Solar R&D report, "DOE should continue its lead role in resource assessment, including estimates of biomass production and feedstocks, the location of and availability of unused wastes, and collection of other data."

What activities will be carried out in those areas in the FY 1984 budget request?

A 3. No funds are requested for these activities in the FY 1984 DOE budget request. The Department of Agriculture - Forest Service, has been authorized, by the McSweeney - McNary Act of 1928, to obtain estimates of the nation's forest resource extent, volume, growth and depletion. Changes in utilization practices gradually extended these measurements to include not only material for lumber, But for pulpwood and now total biomass for energy purposes. This means a mechanism currently exists for which the Forest Service has long had lead responsibility to assess forest biomass resources on a nationwide basis.

Biomass

Question 4: The draft DOE Biomass program plan (Summer 1982) states, relative to the short rotation woody crops program, "Research is needed...to screen and genetically improve species and to identify cost-effective cultivation and harvesting techniques." "Several pilot plants will be required in different areas of the country to prove economic feasibility," it concludes.

If research is needed in these areas, according to your own program documents, why are no funds being requested for it in the FY 1984 DOE budget request?

Answer: The draft DOE Biomass program plan did identify the need to screen and genetically improve short rotation woody crop species, identify cost effective cultivation and harvesting techniques, and establish several pilot plants. However, this plan was careful to point out that such research and development activities were best accomplished by the private sector. Industry has the capability to conduct the research required for short rotation woody crops; as an example, the Packaging Corporation of America has established 4,000 acres of short rotation hybrid poplar near Filer City, Michigan.

Wind

Question 1: Would you explain what policy you use in allocating funds between horizontal and vertical axis systems?

Answer: In allocating funds between the two types of technology, the Department considers a number of factors including the technical maturity of each concept; the level, if any, of industrial R&D; and the degree that the proposed research would resolve remaining technical uncertainties.

Over time, the DOE wind program emphasis has evolved from small and intermediate horizontal axis technology to large scale horizontal technology. The Department has funded development of vertical axis technology over the history of the program. As the large scale horizontal axis projects like Mod-2 and Mod-5 are brought to an orderly conclusion, the program will transition to a research effort that places nearly equal emphasis on horizontal and vertical axis systems.

Wind

Question 2: When do you anticipate the government will no longer need to fund the Rocky Flats Test Center?

How much of the operation was funded by industry in FY 1982 and the first six months of FY 1983, e.g. What funds came in from industry for activities during these two periods?

What is the level of funds needed to sustain the industry testing activity at Rocky Flats?

Answer: Funding for the test center is targeted through FY 1984. It is anticipated that the need for Federal support will diminish over time as requests for services increase; hence, cost for operations would be increasingly offset by fees as the industry matures and more capital is available for private test activities. It is anticipated that the rate of growth of such testing will take some time.

Fee-paid testing by industry was about $20,000 in FY 1982 and is expected to be $30,000 in the first six months of FY 1983. Maintaining the critical mass of skilled professionals and equipment for testing in the current configuration requires approximately $1.5 million annually.

Wind

Question 3: Please provide the status, schedule and plan for the Mod-2 program to the end of government involvement and disposition.

Answer: To date, the DOE sponsored Mod-2 wind turbines comprising the cluster at Goodnoe Hills, WA, have been operated over 3,400 hours during initial testing, generating about 4 gigawatt hours of electricity while synchronized to the Bonneville Power grid. Although initial structural, aerodynamics, and environmental tests were successfully conducted at the Mod-2 cluster in FY 1982, presently the cluster is not operating because of a failure in the low speed shaft which is an integral part of the power train. Corrective actions have been recommended and are presently being incorporated in a redesigned shaft. The wind turbine cluster will be repaired and full test operations will occur in FY 1983 and FY 1984 with FY 1983 funds. Research tests on wakes, aerodynamics, structural dynamics, microscale turbulence, acoustic noise, and electrical parameters are planned. Disposition plans will be developed in FY 1984 allowing for the completion of DOE funded research testing.

Wind

Question 4: Please provide the status, schedule and plan for the Mod-5 program. How much government money has been expended and how much was used by the two prime contractors and how much was used on government R&D activities?

Answer: The Mod-5 wind turbine program, which began in mid-1980 as parallel development projects by the General Electric Co. (Mod-5A) and the Boeing Engineering and Construction Co. (Mod-5B), will continue in FY 1983 under government/industry cost shared agreements. Congress has funded the Mod-5 program at $18 million in FY 1983 of which approximately $2 million would be used for government management and supporting research and technology development. Funding through FY 1982 totaled $31.4 million, with approximately $4 million dedicated to project management and supporting research. We are now continuing the design and component development testing of the two prototype machines. Both designs use significantly advanced aerodynamics, controls, and materials, with each machine being rated over 7 MW. No government funds are requested for FY 1984, and completion of design, fabrication, installation and operational testing will be the responsibility of the private sector.

Wind

Q 5. The Wind Energy System Act Studies report has not been provided on a timely basis and has not provided useful information to us. Do you propose to correct these problems with the $300,000 designated for this activity in the FY 1984 budget?

A 5. The amount requested supports preparation of the Comprehensive Program Management Plan (CPMP) as well as related planning and management studies. Public Law 96-345 requires that the CPMP be submitted annually with the budget request. In preparing the current update of the Plan we have discussed CPMP issues with your staff, and as a result have increased emphasis on presentation of program activities and rationale. The updated Plan has been delayed somewhat due to uncertainties about the FY 1983 budget earlier this year. It will be available soon and we hope that it will provide the information needed on top level program strategy and decisions.

Wind

Question 6: How can you manage these solar programs effectively without any long range plans?

Should we add a proportionate amount to all of the solar and conservation activities to provide for this type of planning activity?

What did the last Wind and OTEC reports cost, respectively?

Answer: The Department does conduct long-range program planning to determine R&D needs and the results of the planning exercises are reflected in the annual budget request. Planning activities are conducted by program staff and program managers as well as by key technical staff in the field organizations. Annual updates to the long-range program planning requirements are provided as necessary. This type of multiyear planning helps the various programs provide the stability and continuity essential to solar energy R&D programs.

A specific amount of funding for planning purposes is not necessary. All of the programs under the jurisdiction of the Office of Conservation and Renewable Energy undertake long-term R&D planning; therefore, there is no need or requirement for funding any new planning initiative.

Preparation of the first revised Wind CPMP and the required Performance Study in Actual Applications cost approximately $150,000. The Ocean Systems CPMP cost approximately $90,000.

Wind

Q 7. Please provide a status and projected milestones for all wind systems modeling activities.

A 7. Computerized modeling and simulation of various aspects of atmospheric fluid flow and wind turbine operation and vibration have been a major thrust since the wind energy research program began in 1973. To date, several dozen distinct computer models have been written. Some are outdated and are no longer in use but other major computer programs are being used continually. The models are also constantly being revised to improve their accuracy or capability and to validate their predictions with field test data from advanced machines. Attached is a list of key modeling efforts and their status.

KEY WIND TURBINE COMPUTER MODELS

	Model	Status
DMST	- Double Multiple Stream Tube Performance Model for Vertical Axis Turbines	Refinement and Validation Underway - Texas Technical University
FFEVD	- Linear NASTRAN-Based Forced Finite Element Structural Code for Vertical Axis Turbines	Being Developed and Validated on 17M and Other Darrieus Turbines
PROP	- Momentum Deficit Performance Prediction Model for Horizontal Axis Turbines	Developed and Published
MOSTAB	- Rotor Aeroelastic and Structural Load Prediction Model for Horizontal Axis Turbines	Development Complete. Published by NASA.
MOSTAS	- Horizontal Axis Turbine System Load Prediction Code	Refinements Being Developed for Advanced Concepts Such as Variable Speed, Aileron Controls, etc. Validation Will be Done on Mod-0 and Mod-2
Wind	- Refinement of PROP for Aileron and Spoiler Controlled Rotors	Being Developed with Wind Tunnel and Mod-0 Validation Underway
STRS-2	- Single Tower Rotationally Sampled Wind Turbulence Model	Development Underway. Verification on Mod-2 Scheduled for FY83/84

OTEC

Question 1: Please provide the rationale for not requesting OTEC funds in FY 84.

Answer: The DOE has concluded that OTEC technology has advanced to the point where further activities can and should be undertaken by private enterprise. Work to date has resulted in improved heat exchangers, procedures for controlling biofouling, methods to fabricate and vertically deploy a several thousand foot cold water intake pipe, and detailed oceanographic data collection. Feasibility of OTEC at the 10 kilowatt level has been demonstrated by mini-OTEC, an industry deployment in which DOE participated. Megawatt scale heat exchangers and other subsystems were successfully operated on-board OTEC-1, deployed off the coast of Hawaii.

It is anticipated that Federal support of ocean energy systems can be terminated after FY 1983. With technical progress achieved to date and with completion of planned activities, there should be sufficient resolution of technical uncertainties to allow and encourage the private sector to continue the development and utilization of OTEC systems if their market potential is sufficiently promising.

OTEC

Q.2. What is the status of the OTEC program and what do you plan to have accomplished with the FY 1983 funding?

A.2. Work to date has resulted in improved heat exchangers, procedures for controlling biofouling, methods to fabricate and vertically deploy a several thousand foot cold water intake pipe, and detailed oceanographic data collection. In addition, improvements have been made in the major components of the OTEC system, including the platform, energy conversion system, station keeping (mooring) system, and electric power cables. Large scale at-sea construction experience is already available as a byproduct of the offshore oil industry. Feasibility of OTEC at the 10 kilowatt level has been demonstrated by mini-OTEC, an industry deployment in which DOE participated. Megawatt scale heat exchangers and other subystems were successfully operated on-board OTEC-1, deployed off the coast of Hawaii.

In May 1982, two DOE award recipients began work on conceptual design studies for a 40 megawatt OTEC pilot plant. A follow-on preliminary design phase is being undertaken with Fiscal Year 1983 funding. Additional FY 1983 work includes a 1/3 scale model cold water pipe deployment experiment, a seawater test of certain open cycle components, completion of one year of data collection on biofouling and corrosion control, refinement of environmental computer code and geophysical data, completion of riser cable safety and integration studies for shelf-mounted platforms, and completion of modifications to the Seacoast Test Facility.

OTEC

Q.3. If we decide to continue the OTEC program at a $10 million or a $20 million level, what do you see as the most productive objectives for a program at each of those levels? What are the key technological issues that require solution?

A.3. The DOE has concluded that OTEC technology can and should be commercialized by private enterprise and that the remaining technical uncertainties are within the capability of private industry to address. Some technological issues which remain to be addressed are:

- Ocean Engineering - cold water pipe deployment, retrieval, inspection, maintenance and repair techniques.
- Open Cycle Systems - uncertainties about open cycle surface condensers, erosion characteristics and performance and biofouling characteristics.
- Closed Cycle Power Systems - long term effects on heat exchangers used in OTEC operating conditions, and cost reduction of pumps, turbines and heat exchangers.
- Biofouling - uncertain chloride levels required in closed cycle OTEC plants, uncertain control requirements for open cycle OTEC plants.

OTEC

Q 4. There are activities that have been conducted within OTEC that are not directly ocean thermal related such as the fuels activities. Do you believe that these activities have promise and do you plan to consolidate them into one organization?

A 4. The assessment of OTEC fuels activities have indicated that methanol derived from coal using OTEC generated electric energy can be economically competitive in today's OTEC market using available chemical industry processes and equipment and projected plantship costs. There is no need to combine the OTEC activities with other DOE fuels activities since this effort consists only of economic assessments of various electric energy use options and is being concluded.

Q 5. Do you believe the OTEC technology has application to bottoming cycles and other low grade heat applications?

A 5. Technical and economic evaluation has indicated that OTEC technology does have application to bottoming cycles and other low grade heat applications. For example, recent studies have indicated that OTEC systems can, in some instances, be combined with low grade geothermal resources to provide economical power. Following an ongoing joint assessment effort with DOE, the Navy may proceed to design and build a "GEO-OTEC" power plant for their facilities at Adak, Alaska.

Mr. **Fuqua**. Very good. We are pleased that it was very successful.

Mr. Tribble, it is my understanding that your staff is in the process of preparing a deferral package for several conservation and solar programs, including the MOD-5 wind machine and also part of the Residential Conservation Service.

When Secretary Hodel was before the committee, he indicated that it was his intention to spend all the funds appropriated by Congress in these areas. Also, when the staff met with you, I think back in late January, they reported to me that that was your intent.

It seems to me that this is somewhat inconsistent with what the Secretary said and with the conversations and briefings between yourself and the committee staff.

Mr. **Tribble**. We have been asked to suggest places where a deferral might very well be appropriate. We have done some very preliminary work in preparing information on a number of different items, and this has not been acted upon in the Department. We do not, at this time, know whether or not it is going to be a recommendation. Information is being gathered. No decision has been made at this time on what use it might be put to.

Mr. **Fuqua**. Was this initiated by OMB, or was this an internal initiative by DOE?

Mr. **Tribble**. I am sorry; I do not know the origin. It did originate outside of the Office of Conservation and Renewable Energy.

Mr. **Fuqua**. It was not initiated in your office, then?

Mr. **Tribble**. That is right.

Mr. **Fuqua**. The staff reminds me that in the last of January, they requested an item-by-item breakdown of the spending plans for conservation for fiscal year 1983. It has been routinely provided to staff at their annual DOE program briefing.

Yesterday, they received the requested information, but only $24 million out of the total conservation R&D budget of $75 million was covered. They are having a little difficulty getting the details for fiscal year 1983 spending plans.

Can your office provide our staff with the activity charts in these areas?

Mr. **Tribble**. Yes. Certainly we can. I thought it had already been done.

Mr. **Fuqua**. Thank you.

We also sent, on February 17, some questions requesting written response in preparation for these hearings, and we have not received those responses as yet.

Mr. **Tribble**. I am sorry that they have not gotten to you as of yet. They are in process, and I just have to apologize for the fact that they have not reached you yet.

Mr. **Fuqua**. Is there any estimate of when we might expect them?

Mr. **Tribble**. I have to say they have left my office.

Mr. **Fuqua**. How long ago did they leave your office?

Mr. **Tribble**. As you know, we had quite a few over several days and weeks. Some left last week. I think the latest ones left as late as late yesterday afternoon.

[The questions and answers were provided to the subcommittee on March 23, 1983.]

Mr. **Fuqua**. I would hope that they would be forthcoming very shortly.

Can you provide the dollar value of the procurements that have been signed off by the Office of Conservation and Renewable Energy in fiscal year 1984 as of March 1?

Mr. **Tribble**. Yes. We did get into that. About $100 million has been signed out.

Mr. **Fuqua**. $100 million?

Mr. **Tribble**. Yes.

Mr. **Fuqua**. Can you give us a breakdown of that? You can supply that for the record if you like.

Mr. **Tribble**. I have quite a list. I will be glad to supply it for the record, or I can read it now if you would prefer.

Mr. **Fuqua**. If you could read it now, that would be fine.

Mr. **Tribble**. All right.

In the active solar heating and cooling, appropriation, $6.65 million; authorization, $3.343 million as of March 1.

Passive solar heating and cooling: appropriation, $5 million; authorization, $2,123,000.

Photovoltaics: $58 million—I will just round these off—authorization, $14 million; solar thermal, $49.5 million; $9.9 million; biomass, $16 million. Only $423,000 has been authorized there.

Alcohol fuels R&D: $5 million appropriation, $4,183,000 authorized. Wind: $31 million appropriated; $5.3 million authorized.

Oceans: $10.5 million appropriated; $3.6 authorized. Solar international: $10 million appropriated, $9.5 authorized. Solar information: $3 million appropriated, $2.1 million authorized.

Solar program support: $1 million appropriated; $270,000 authorized. Solar reserve account: No new fiscal year 1983 appropriation but $228,000 authorized from carryover funds.

In the conservation R&D program, buildings and community systems, the appropriation was $36 million; $11 million out. Transportation, $53.9 million appropriated; $50.8 million authorized. Industry, $27.9 million appropriated, $11 million authorized. Energy conversion technology: $9.2 million appropriation; $5.2 million authorized.

Electric energy systems: $17.2 million appropriated, $6.7 million authorized. Energy storage systems: $25.7 appropriated; $16 million authorized.

To summarize those, in the conservation categories, there were $169 million appropriations; $100 million authorized. In renewal energy, $255 million appropriated; $55 million authorized.

Mr. **Fuqua**. In solar international, the $9.5 million, how much of that is for the Saudi Arabia project?

Mr. **Tribble**. All of it.

Mr. **Fuqua**. All of it.

There is something about your conservation budget that really perplexed me. It is my understanding that you requested $51.4 million to OMB in 1984, and they raised it to $101 million, including electric energy systems and storage.

What caused their change of heart, or why was it so low to begin with?

Mr. TRIBBLE. The change here reflects the commitment that Secretary Hodel made in his earlier testimony that we would come forth with perhaps a more realistic program, one that more nearly reflected the wishes of Congress.

After the original proposals were made and he expressed the desire to raise the level of the activities, we did, then, submit additional expenditures, and that was the reason for the increase.

Mr. FUQUA. So you requested the increase and they approved it, then?

Mr. TRIBBLE. That is right.

Mr. FUQUA. There is a great deal of concern, with the dismissal of some senior personnel, particularly in the conservation area, that maybe you do not fully trust their ability or maybe trust them. Is there any validity to that?

Mr. TRIBBLE. No. I cannot imagine where that derived from.

Mr. FUQUA. Why were they dismissed? For inability to perform?

Mr. TRIBBLE. I know of only two people in the top management of the organization who are not there any longer, and one of those resigned to accept other work.

Mr. FUQUA. There is no funding for indoor air quality research. What activities are being terminated as a result of this elimination in the budget?

Mr. TRIBBLE. We have been developing instruments to measure indoor air pollutants, and this work has been completed. In addition to that, there has been a great deal of knowledge gained about what indoor air pollutants derive from, what their sources are, and we feel that perhaps we do not know all there is to know about it at this time, but we have come a long way toward satisfying the requirements that will be brought about as we close up buildings and reduce infiltration.

Indoor air pollution will be site specific—individual buildings in the same immediate vicinity would have different problems—so we think that the instruments that will enable us to detect indoor air pollutants are perhaps the most important part of that program.

We are going forward with some additional data collection on this subject. This was one of those things that was discussed in our workshop. If there are other needed research programs that come out of those recommendations, then certainly we would expect to give careful consideration to those.

Generally, to answer your question, we think we have learned a great deal about the indoor air pollution problem, and we just simply do not see the need for a continued level of effort.

Mr. FUQUA. In the energy conservation and utilization technologies, it was originally scheduled, I think, to reach about $25 million by fiscal year 1984. In your budget for 1984, that has been reduced from, I guess, $9 million in 1983 down to $3 million in 1984. Can you explain why you are reducing that amount?

Mr. TRIBBLE. Yes. A lot of the work that was in the energy conservation and utilization technologies [ECUT], was the kind of work that cuts across technologies. Combustion work was one of those.

We are going forward with some further combustion work there. On the other hand, we have learned a great deal about internal engine combustion. The automotive manufacturing concerns are picking up on this and are using the facilities that we have and participating in this research.

Some of the materials work that has been in that sector is now being done in the transportation sector because it was largely ceramics work.

The heat exchanger work that was being done is being completed. This was work that was examining the failure of heat exchanger tubes because of vibrations, and by the end of fiscal year 1983, we believe we will have that project completed.

Mr. **Fuqua**. But the work in the ceramics probably would have never been started had it not been for the DOE activities, particularly as it relates to engines, turbo engines.

Mr. **Tribble**. That is quite possibly true. On the other hand, we have known for many years that we could increase the efficiency of many industrial processes if we could accommodate higher temperatures.

And so I think that, while this investigation has certainly been accelerated by the DOE programs, industry would eventually get around to the need for it. There are many uses to which ceramics can be put other than the engine parts.

Mr. **Fuqua**. Mr. Lujan and I have again introduced our bill to increase the solar tax credits for businesses to 25 percent and extend them through 1990. That includes solar, wind, geothermal, OTEC, and associated technologies.

What is your estimate of what the impact of the bill would be on market penetration and the advancing renewable energy technologies such as photovoltaics and wind and solar thermal, geothermal, OTEC, et cetera?

Mr. **Tribble**. There is no question that the tax credits that now exist have provided substantial support to these technologies.

I would not like to be held to this figure, but I understand that the tax credits that have been allowed in recent years in these areas amount to on the order of $700 million a year. There are a lot of projects that meet the ROI hurdles by virtue of the tax credits that would not otherwise meet them.

So there is no question that tax credits do in fact help.

We at the Department of Energy have taken the position that we would like to see the tax credits continued. At the same time, we realize that this is a parochial view and may very well be overridden by considerations not within our responsibility.

Mr. **Fuqua**. But basically, you do support the tax extension?

Mr. **Tribble**. Yes.

Mr. **Fuqua**. In a report prepared by Strategies Unlimited for the Solar Energy Industries Association, there was a recommendation, and I quote, "Technology development activities merit expansion within the DOE program. These activities frequently entail high risks for industry, yet might potentially yield large rewards for the technology."

Yet, in light of that, you have terminated the photovoltaic technologies development in the fiscal year 1984 budget request.

Mr. **Tribble**. Did you say we had terminated photovoltaic development?

Mr. **Fuqua**. The technology development activities.

Mr. **Tribble**. Let me ask my friend, Dr. San Martin, to respond to that. I am not aware that we have terminated it. It doesn't sound right.

Dr. **San Martin**. Mr. Chairman, it is accurate to say that there is less emphasis in our 1984 budget on activities beyond the research phase, but all technology development activities have not been terminated.

For instance, our budget request does include $6.5 million for analysis, testing, and reliability studies, and these activities do include the collection and analysis of data from cells and modules in different configurations and working toward that end.

Mr. **Fuqua**. So you do have $6.5 million for technology development?

Dr. **San Martin**. Yes, sir.

Mr. **Fuqua**. The ERAB solar report recommended the following activities: Development of promising technologies that improve the integration of individual process step; development of advanced processing equipment; cost-reduction techniques for single-crystal silicon materials; concentrator systems R&D; advanced silicon test R&D. No reference has been made to any of these activities in the 1984 budget request. Can you expand on that?

Mr. **Tribble**. Generally speaking, the programs that we have ongoing and planned coincide with the recommendations of the ERAB solar panel. There are, of course, some places where we differ. When we get down to that level of detail, I suspect there is a good reason why we are not doing that.

Let me ask Dr. San Martin if he would like to comment further on that.

Dr. **San Martin**. Mr. Chairman, if I could, I would like to confirm Mr. Tribble's statement that we believe the proposed photovoltaic program is highly consistent with the ERAB solar panel recommendations.

For instance, our activities in solar materials research will continue to a logical completion, and we will continue development of process steps until such an activity has been fully integrated. We expect that to occur toward the end of calendar year 1984.

There will also be an emphasis on the identification and development of advanced processes such as thin-film deposition techniques, which are required by industry to design and build equipment for such production.

In addition, the single-crystal silicon materials development effort is nearing its logical completion which we believe can result in the establishment and the successful transfer to industry of process steps that are capable of reducing the cost of high-purity silicon to less than $20 a kilogram, whereas currently that sells in the marketplace at close to $60 a kilogram.

In the concentrator systems research and development area, we have field tested first-generation technology that has already been demonstrated. Second-generation technology systems are under laboratory testing. The development of third-generation systems is actually underway at this time.

This effort, however, must progress at a pace that is consistent with the collection, evaluation, and application of first- and second-generation information that we have gathered and are gathering.

The development of advanced silicon ribbon technology, for instance, is continuing into 1984. We will be pursuing the most promising of the four ribbon technologies that are currently under development, and we will be selecting the most promising one for continued research, especially in the critical areas of stress and strain involved in that particular technology.

This effort, we believe, has been very successful, and it has advanced to the stage where private manufacturers are developing inhouse processing equipment for their own use that best suits their own processes.

Mr. **Fuqua**. In the field of biomass, the ERAB report talked about genetic research on crop and forest plants and investigations of new species to determine their potential for biomass energy production. It also mentioned collecting and harvesting technologies.

Do you have any funds for these programs in this budget request?

Mr. **Tribble**. No; we do not.

In the field of short-rotation woody crops, we have identified a number of species that are quite rapid growing. Some of the activities that we have will be carried forth to a proper conclusion with existing dollars.

In addition to that, there is a tremendous amount of work of this nature that is being undertaken by the forest products industry. I am sure you are familiar with some of that. We feel that we have brought this technology to the point where, when it becomes economical for them to have energy plantations, if you will, they have the means with which to go forward with it.

Mr. **Fuqua**. Likewise, in the same ERAB report, they talked about the solar thermal program, saying that there should be a redirection of emphasis to the parabolic dish program because of its potential high efficiencies and lower costs.

It is my understanding that no funds are provided for the parabolic dish technology.

Mr. **Tribble**. I am going to ask Dr. San Martin to respond to that.

Dr. **San Martin**. Mr. Chairman, our request in 1984 sustains a low level of activity, primarily in materials research, to develop both high-performance and light-weight concentrators and high-temperature, high-flux materials for receivers.

This effort supports long-term parabolic dish development. The short-term experiments, which include the first and second small community parabolic dish experiments, will be completed with prior-year appropriations, and they should result in valuable information to the industry.

Mr. **Fuqua**. Mr. Lewis?

Mr. **Lewis**. Thank you, Mr. Chairman.

Could you give us a status report on the Barstow solar project?

Mr. **Tribble**. Yes; it is doing quite well. The Barstow facility is in its test phases. It is being operated as a test bed during the week and, during weekends, it is being put on the line to deliver power to the grid. I understand that it has met all of the design requirements insofar as capacity of output is concerned. They have operated it on a 24-hour basis with storage.

So, it has met all of its current tests and is one of our success stories.

Mr. **Lewis**. There are several key management positions not filled in the Department, such as the Under Secretary who is responsible for R&D. Do you have any idea as to when that position may be filled so we would have somebody that is going to head the R&D development in the Department of Energy?

Mr. **Tribble**. No, sir, I do not. That is not my area of responsibility, and I am sorry, I don't have any information on that.

Mr. **Lewis**. How about the Deputy Assistant Secretary for Conservation and Transportation? Is that under your jurisdiction?

Mr. **Tribble**. Yes; and that position is filled on a temporary basis at this time. We are in fact making efforts to fill it on a permanent basis.

Mr. **Lewis**. You stated in your testimony that the Federal Government should provide at least sufficient high-level interest and support for conservation and renewable activities to maintain the momentum achieved so far.

How does this coincide with your requested budget statement?

Mr. **Tribble**. In the past, as you know, we have spent a good bit of money on demonstration activities and buying and building hardware. We are redirecting that program away from building demonstration projects to more research activities.

The objective that we have now is to maintain a close relationship with the industry in all of these technologies, determine what they are doing in research to be sure that we are not competing with them, but, at the same time, determining where there may be gaps in the research that they, for one reason or another, do not feel that they can finance. We are trying to direct our efforts into those areas so that, generally speaking, and on an overall basis, we will move the technologies forward as fast as they can be moved forward.

Mr. **Lewis**. Does this coincide with your philosophy of reducing the budget in the solar area?

Mr. **Tribble**. The budget is automatically reduced when you turn away from the expensive demonstration projects.

For example, the Barstow facility that you just mentioned, had a total cost on the order of $140 million to $160 million. We are not building any more of that kind of facility, which does, of course, have the effect of reducing the total dollars in the budget.

Mr. **Lewis**. Is there a difference between what you are saying and R&D in order to further advance the state of the art from a demonstration project?

Mr. **Tribble**. I am sorry. I did not understand that question.

Mr. **Lewis**. You are bringing out that you are reducing the budget because you are reducing some of the demonstration projects.

Mr. **Tribble**. Right.

Mr. **Lewis**. In research and development, isn't it a fact that you want to continue to have the demonstration projects so you can continue to further the R&D into the state of the art?

Mr. **Tribble**. The demonstration projects are generally not necessary to advance the R&D. In many instances, there does need to be a test-bed facility, certainly, of a prototype nature, for example.

But a large part of the budget in years gone by was for multiple installations of such things as flat-plate collectors, parabolic troughs, and things of this nature.

I think that our proposed budget is consistent with this inasmuch as we are aiming virtually all of our effort now toward research.

Mr. LEWIS. Well, I have difficulty in understanding your answer. How do you get from A to Z in a research and development project if you want to advance the state of the art and you do not fund it properly? Your development is in various stages from a prototype into an actual, so you are interested in the prototype, but how do you know you are at the prototype and cannot make a better prototype if you do not continue the state-of-the-art activities?

Mr. TRIBBLE. The industry has been developed substantially in recent years. They are building a lot of the equipment that we would otherwise be building as a prototype. They are moving it into the marketplace—for example, photovoltaic arrays, wind machines, flat-plate collectors, of course, parabolic troughs. These technologies have been picked up by industry.

And so, other than for us to conduct research where we can make improvements with respect perhaps to materials that they may use, the longevity of the materials, there is little need for further Federal involvement.

Mr. LEWIS. Have you had any indication, Mr. Tribble, that utilities are picking up the further R&D after your demonstration projects?

Mr. TRIBBLE. That the utilities are picking them up?

Mr. LEWIS. Utility companies or private sector. Let me put it that way.

Mr. TRIBBLE. One that comes to mind is that we did have a program on compressed air storage for generation of on-peak power, and this is being picked up by EPRI.

Some of the work that we have been doing in that field was highly specialized; for example, a magnetic storage mechanism that we have built and which is being installed for testing at Bonneville Power Administration. I am sure that no utility is going to pick up on that until after we have demonstrated whether or not the system does in fact work as it is intended.

Mr. LEWIS. Do you feel confident that the private sector will pick up the MOD-5, the wind machine?

Mr. TRIBBLE. That is difficult to answer. The wind program is moving along quite well.

Mr. LEWIS. This is what I am talking about, the state of the art.

Mr. TRIBBLE. Yes; the small wind machines are being manufactured now by, I think, more than 20 companies, and their sales are rising.

In the large wind machines, we are still conducting tests on the MOD-2's at Goodnoe Hills, and there is a great deal that we still need to learn from the testing. The MOD-5 is the next generation of design and is in the design stage now.

As to whether or not there will be a demand so that the industry would pick it up, it is difficult to say, particularly now in view of the lowered cost of fuel. The design is progressing. We do really feel that it is coming along too early on the heels of the MOD-2 for us to be able to apply the lessons we expect to learn from the MOD-2 to the MOD-5.

Mr. **Lewis**. Thank you, Mr. Chairman.

Mr. **Fuqua**. Mr. Lowery?

Mr. **Lowery**. Thank you, Mr. Chairman.

Mr. Tribble, could you outline a little bit more the status of the No. 2 and No. 3 slots at Energy and what timetable is being looked at to fill those positions?

Mr. **Tribble**. I am not sure I understood that.

Mr. **Lowery**. Well, I understand that there are vacancies in the No. 2 and No. 3 slots at Energy.

Mr. **Tribble**. Yes, but that is not in my area of responsibility, and I do not have any influence on it.

Mr. **Lowery**. The Secretary has not chatted with you on that subject?

Mr. **Tribble**. That is right.

Mr. **Lowery**. He has not asked for your input.

Let's get into Heber, then.

Mr. **Tribble**. All right.

Mr. **Lowery**. That is in your responsibility, or maybe it is not, either, in terms of its being zeroed. Am I correct in my understanding that the contracts were signed and the $29 million for fiscal year 1983 will complete that project?

Mr. **Tribble**. That is my understanding, but I would like to ask Dr. San Martin if he would like to comment on that.

Mr. **Lowery**. And if you could, please give us a bit of a status report as well.

Dr. **San Martin**. Yes, Mr. Lowery.

Our contractual commitment for the Department of Energy's 50 percent cost sharing of the Heber project amounted to a total contribution of $61 million. We complete our total financial commitment to the Heber project with fiscal year 1983 appropriations.

The status of the project at this particular time is that it is methodically progressing. We are approaching the point where we are to undertake a full 100 percent review of the final design of the project. We have already entered into contracts for some of the long-lead items required.

We dedicated the facility, and the chairman was able to attend and participate in those groundbreaking ceremonies at the end of last year. Right now, if I were to look at the many, many events that yet have to take place for such a large and complex project, the one that we are watching most carefully at this time is the deliberations of the California Public Utility Commission. We hope that, within the next 30 to 60 days, they will have been able to have responded formally to San Diego Gas and Electric's petition for the handling of the cost on the Heber project.

Mr. **Lowery**. To put that into the rate base?

Dr. **San Martin**. I am personally not familiar with the technicalities of their petition, but I am sure that a significant amount of the costs are proposed to be in the rate base.

Mr. **Lowery**. But the project is on schedule and progressing?

Dr. **San Martin**. Yes, sir.

Mr. **Lowery**. What will the Department of Energy's ongoing program be in terms of monitoring Heber? Will you continue to audit?

Will there be continued reports so that you can continue to update this committee?

Dr. **San Martin**. That is correct, Mr. Lowery. The value of undertaking any activity of this nature is the information that is generated that can then be made available to others so they can decide if it is in their best interests to emulate or further duplicate these types of activities.

The Department of Energy intends to remain involved in that project until its successful conclusion, and we will continue to document progress, activities and knowledge, and to make sure that that is available in the public domain.

Mr. **Lowery**. Thank you, Dr. San Martin.

Mr. Tribble, I guess, if I understand it correctly, having seen the budget over the last 2 years cut by two-thirds, DOE's philosophy is that once you have proven a technology, you cut loose of it, and it is then to be further advanced and applied by the private sector. Is that a correct understanding?

Mr. **Tribble**. With the exception that we continue to maintain contact with the industry, and where there are research activities that they do not undertake for various reasons, then if it will advance the technology, and if we feel that it is in the Nation's interest, we attempt to do those research programs that will permit the private sector to continue to make progress in the development of any given technology.

Mr. **Lowery**. Do you feel comfortable with this budget?

Mr. **Tribble**. Yes; I do.

Mr. **Lowery**. How much is it below what you originally submitted to OMB?

Mr. **Tribble**. As a matter of fact, it is more than we originally submitted to OMB. We had a reconsideration after Secretary Hodel became Secretary of Energy, and we reevaluated the program and substantially added to the overall program for conservation and renewable energy.

Mr. **Lowery**. If you substantially added to it, it must have been down around zero on the first cut. [Laughter.]

Mr. **Fuqua**. $51 million.

Mr. **Lowery**. Thank you, Mr. Chairman.

Thank you, Mr. Tribble.

Mr. **Fuqua**. Mr. Gregg?

Mr. **Gregg**. I will yield to Mrs. Schneider.

Mrs. **Schneider**. Thank you.

Mr. Tribble, I would like to ask you a couple of questions about the photovoltaic research program. I am curious to know to what degree you have studied the current status of the Japanese program in photovoltaics. In elaborating on that, could you tell me a little bit about what their development plans are for international markets?

Mr. **Tribble**. I think Dr. San Martin can give you a much better answer to that question that I could, so I am going to call on him if I may.

Mrs. **Schneider**. All right.

Dr. **San Martin**. Mrs. Schneider, in working with our laboratory experts and several consultants, we feel that we have a very good understanding of the Japanese efforts. We are not privy to their specific plans with regard to international marketing, but I would like to point out that U.S. industries currently dominate photovoltaic sales worldwide at this point, and the Japanese do have a substantial effort under way.

I would characterize it as one that is working toward trying to catch up with the United States. The Japanese have only one area that I can identify where they are currently exceeding U.S. industries in the field of photovoltaics, and that would be in what I would call amorphous silicon photovoltaics, and that is in developing, in essence, solar batteries for the number of consumer products where Japan currently dominates the world market, and that would be wristwatches, calculators, et cetera.

Our focus in the United States is not in developing consumer products but in developing the technology so that it can be used for supplying energy to our own domestic needs and also giving our industry a continued opportunity to be very competitive in international sales.

So, overall, I think that we are clearly in a leadership position in this country in that particular technology, and I expect that that will continue.

Mrs. SCHNEIDER. That is not the information that I have, and I wonder if you might be able to provide me, at some point in the future, with some information that could amplify those statistics of the United States leading in the world market. I would really appreciate that.

Dr. SAN MARTIN. Certainly.

On March 21, 1983, Dr. San Martin met with Mrs. Schneider to personally discuss the statistics.

Mrs. SCHNEIDER. Did the United States participate in the U.S. AID-sponsored trade fair that was held in Zimbabwe not too long ago? Did DOE participate in that energy trade fair?

Dr. SAN MARTIN. Mrs. Schneider, AID is, of course, not a Department of Energy entity; it is affiliated with the State Department.

The Department of Energy has been supporting the Department of Commerce, which has primary responsibility for enhancing trade opportunities for our industry. We are continuing to do that this particular year.

With regard to that specific activity, I just cannot recall, from my own memory, whether there was other U.S. Government participation in addition to AID or not.

Mrs. SCHNEIDER. I am interested in the growth potential for photovoltaics here in the United States. Evidently, in 1978, as the program was established by Congress, there were set up production targets, and those targets were 2,000 megawatts of cells by 1988 and about one quad or 50,000 megawatts by the year 2000.

Given that these targets, I presume, have been perceived to be now a bit optimistic, I wonder if the Department of Energy has revised those targets at this time and what they might be.

Mr. TRIBBLE. We do not believe that, given the many uncertainties that would influence production of photovoltaics or any other form of energy, it is realistic to set a target. It is certainly going to depend upon the economic conditions that exist. It is going to depend on the cost of fossil energy. It is going to depend on the success in research that we are able to achieve.

I have watched a number of target projections over the past 10 years, many on the price of oil, and have found that they are generally not very accurate.

Our objective is to move forward with the technologies as rapidly as we can and let the marketplace respond to these various influences and move the technologies as rapidly as we can.

Dr. SAN MARTIN. If I could amplify for 1 second, the photovoltaic industry has been growing at a very fast rate. In the last couple of years, it has grown in excess of 50 percent per year. There are few industries in existence that are growing that fast.

The week before last, the Department sponsored an annual review of photovoltaic technology here in town, and there were a number of industry representatives who were forecasting that 1983 may be the very best year that photovoltaics has ever experienced, with a potential that the industry might increase by maybe even 100 percent.

Mrs. SCHNEIDER. Well, what I am concerned with is that you are talking about the free market approach, which is fine, but we are also here talking about the budget and the dollars that are being expended on photovoltaics. I seem to be getting mixed signals. Is what you are saying implying that the Federal Government should not even be putting any money into the photovoltaic budget, based on the fact that you do not have a game plan or targeted dates or anything for development purposes? You are leaving the international development up to the Department of Commerce. You are leaving the expanse of increasing the number of megawatts to whether or not the price of fossil fuel goes down. Mr. Tribble just said that it is not realistic to set a target.

To me, all of those responses are very confusing. It seems if we are going to appropriate money for a photovoltaic program, we just don't want to keep throwing money at this idea or concept or development program, but, rather, we want to see increments of improvement by our investments in that area.

From what you are saying, you don't have any game plan, either domestically or internationally.

Mr. TRIBBLE. I am sorry I did not communicate more adequately. We do, in fact, have a game plan, and our game plan is to do the research that is necessary to move the industry forward. This is proving to be quite effective.

The increases in the production facilities and the production sales that are taking place in the industry are building upon the research that we have done. In addition, we are making every effort to go forward with those things that will be necessary to keep United States industry in the forefront of the technology.

We believe that if we do that, and if the products of the American industry are best, this will be a successful program.

Mrs. SCHNEIDER. I believe that is all the questions I have for now, Mr. Chairman. Thank you.

Mr. FUQUA. Mr. Gregg?

Mr. GREGG. Thank you, Mr. Chairman.

Do you work in geothermal technology?

Mr. TRIBBLE. Yes.

Mr. **Gregg**. What are the chances that there will be an additional geothermal site in the Northeast, or east of the Mississippi?

Mr. **Tribble**. I am going to respond briefly to that and then ask Dr. San Martin if he would like to add.

Generally, as you probably know, virtually all of the geothermal resources are in the Western United States. In view of the fact that our activities are aimed at research in the geothermal fields, this is where all of our activity is taking place.

The only resource that I know of in the East is some underground water that is in the temperature range of some 120° to 140° F., which is very minimal insofar as geothermal resources are concerned.

We think we would be most productive in working in those areas where there is more of a resource.

Let me call on Dr. San Martin to add to that if he has any additional information.

Dr. **San Martin**. Mr. Gregg, I can only confirm Mr. Tribble's comments that geothermal areas are typically associated with recent volcanic activity. The geological age of the Eastern part of the United States is quite old in comparison to the West, and therefore the opportunities are much, much less in that particular area.

The programs that we have supported that have looked at the possibility or the opportunity for geothermal energy extraction in the East indicate that it is a relatively low-temperature, low-grade resource. This makes it very, very difficult to justify that it can be economically extracted and used at this particular time.

Mr. **Gregg**. Thank you. I guess those are all my questions for the moment.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you.

Mr. Boucher?

Mr. **Boucher**. I have no questions at this time, Mr. Chairman.

Mr. **Fuqua**. Thank you very much, Mr. Tribble. We appreciate you and your colleagues being here this morning.

Mr. **Tribble**. Thank you.

[Additional information requested from Mr. Tribble follows:]

Department of Energy
Washington, D.C. 20585

July 7, 1983

Honorable Don Fuqua
Chairman, Subcommittee on Energy
Development and Applications
Committee on Science and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

Subsequent to the March 8, 1983, hearing before the House Science and Technology Subcommittee on Energy Development and Applications, Assistant Secretary Joseph Tribble was asked to provide a monthly update on contract expenditure of funds for conservation and renewable programs. Enclosed is the June report.

If you have any questions, please call Ingrid Nelson or Tom Pretorius of my staff on 252-4277. They will be happy to assist you.

Sincerely,

Thomas H. Pretorius
for
Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosure

Contract Funding in Thousands

FY 1983

	FY 1983 Appropriation	FY 1982 Unobligated Carryover	Total Obligational Authority	CE Commitments to Obligate thru 6/30/83	Obligations thru 5/31/83
Solar Program					
Active Solar Heating & Cooling	$ 6,650	$ 954	$ 7,590	$ 7,456	$ 3,229
Passive Solar Heating & Cooling	5,000	66	5,051	5,120	3,028
Photovoltaic Energy Systems	58,035	21	57,936	57,620	44,242
Solar Thermal Energy Systems	49,500[1]	4,061	48,488	48,410	29,408
Biomass Energy Systems	16,000	919	16,875	16,678	12,400
Wind Energy Systems	31,400	30	31,420	30,852	30,291
Ocean Energy Systems	10,500	4,440	14,930	10,166	4,975
Alcohol Fuels	5,000	77	5,067	5,067	4,118
International Solar Energy Program	10,000	3	10,003	9,500	9,420
Solar Technology Transfer	3,000	7	3,007	2,720	491
Program Support	1,000	104	1,104	445	273
Solar Reserve Account	0	4,469	4,469	4,050	-78
Total	$ 196,085	$ 15,151	$ 205,940[2]	$ 198,084	$ 141,797
Conservation					
Buildings & Community Systems	$ 36,600	$ 4,552	$ 41,099	$ 32,792	$ 14,131
Transportation	52,400	4,338	56,666	55,454	48,608
Industry	26,400	8,572	34,935	30,851	12,224
Energy Conversion/Utilization Tech.	9,000	423	9,423	9,243	7,564
Electric Energy Systems	16,700	2,528	19,157	18,388	12,789
Energy Storage Systems	25,000	282	25,282	23,831	21,241
Total	$ 166,100	$ 20,695	$ 186,562[2]	$ 170,559	$ 116,557

[1] $5.0M Proposed Deferral in FY 1983.

[2] Excludes amounts proposed for reprogramming in support of the Small Business Innovation Research Program (SBIR).

Mr. Fuqua. The subcommittee will be adjourned.

[Whereupon, at 11:32 a.m., the subcommittee recessed, to reconvene at the call of the Chair.]

1984 DEPARTMENT OF ENERGY AUTHORIZATION

WEDNESDAY, MARCH 9, 1983

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, D.C.

The subcommittee met, pursuant to notice at 9:38 a.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Winn, Sensenbrenner, Schneider, Lowery, Bateman, and Lewis.

Staff present: Dr. Eugene Frankel, science consultant, and Daniel M. Steinway, minority counsel.

Mr. **Fuqua**. We are very pleased to begin our hearings on Conservation and Solar Energy. We have a very distinguished panel of members of the DOE Energy Research Advisory Board (ERAB). We have looked with interest at the recommendations they have made and find they have a lot of commonality with those that have been made by the committee over the years. We are very pleased to have Dr. Ivan Bennett, the Vice Chairman of the ERAB; Vicky Tschinkel, Chairman of the ERAB Solar R&D Panel, and a constituent of mine; Mr. Grant Thompson, Chairman of the ERAB Conservation R&D panel, and Dr. Alvin Trivelpiece, Director of the DOE Office of Energy Research.

Dr. Bennett, I believe you are the leadoff, and we would be pleased to hear from you.

STATEMENT OF DR. IVAN L. BENNETT, VICE CHAIRMAN, ENERGY RESEARCH ADVISORY BOARD ON THE FEDERAL ROLE IN SOLAR AND CONSERVATION RESEARCH AND DEVELOPMENT

Dr. **Bennett**. Thank you, Mr. Chairman. I am happy to have this opportunity to appear before the subcommittee. I want to touch briefly on some of the points in the statement I have submitted for the record. I would like to emphasize the fact that ERAB is an independent advisory committee, which was established by the Department of Energy in 1978. It was charged under the Federal Advisory Committee Act. The Board's role is advisory only, and has no direct role in policymaking. I want to point out that neither ERAB nor I represent the view of the Department. So, when we speak about the solar and conservation reports we are speaking only for the Energy Research Advisory Board. Both the solar R&D

and conservation reports were requested by the Deputy Secretary of Energy.

The solar panel was asked to address four broad questions: One, what specific research objectives should be supported by the Federal Government in each solar technology? Two, what is the present ability and incentive of industry to assume leadership for continued solar development? Three, what mechanisms may be needed to insure an efficient transfer of solar technology developed by Government to the private sector? And, four, what is the appropriate Federal role with respect to each solar technology?

The report addresses each of these questions, and concludes that the primary Federal roles in solar R&D should be in support of basic and applied research, high-risk technology development and other necessary research for which there are insufficient market incentives. In particular, I would like to address the Federal role in solar R&D and in conservation:

The Deputy Secretary asked ERAB, in terms of the conservation report, to address several items: Research and development activities in energy conservation that should be pursued by the Federal Government; the Federal Government's capability as a consumer of energy to conduct R&D in an effort to improve its own use of conservation technologies; institutional restraints and market structures that prevent energy prices from calling forth an appropriate marketplace response in efficiency improvements; and, how the ability and incentive of the various sectors of our economy to conduct effective conservation research both on manufacturing processes and final products can be improved.

Again, the panel's report addresses each of these questions in depth, but I want to only point out that in considering the appropriate Federal role in conservation R&D the panel's findings were similar in several respects to those of the solar report. The question of the Federal role in R&D in these two areas is very important, but how do these R&D programs stack up against other R&D programs? Because the Federal role question is central to all of ERAB's recent studies, we recently undertook a special study to synthesize our views on this issue. Our report, which is entitled "The Federal Role in Energy R&D," was submitted to the Secretary of Energy on February 25 of this year, and will be published by late next month.

The origins of this effort actually date back to the Energy Research Advisory Board report on Federal Energy R&D Priorities in November 1981.

In that study, seven criteria were utilized in assessing energy program priorities. One of these, which was not rigorously applied at the time, was whether or not a Federal role was appropriate. In an attempt to evaluate energy R&D programs in terms of an appropriate Federal role we examined several criteria:

The current and expected future scope and amount of private-sector funding relative to requirements for an orderly R&D program.

The amount of development time to first commercial payoff.

The degree of risk of R&D to private sector development including: Technical risk—that the end product may not be developed, and the market risk that the end product would not attract customers at a price which would be profitable.

Finally, the policy risk—that is the risk that Government policy, with the possibility of policy changes—that would make investment in R&D unattractive. The need for Federal energy R&D involvement to support regulatory, environmental, or policy responsibilities.

On the basis of these criteria, we examined each of the R&D programs and placed them in one of three Federal role categories:

Primary—The Federal Government should be the primary source of support because the industry participation is likely to be small, or the R&D is required to meet the Federal Government's regulatory or policy responsibilities.

Complementary—Some Federal role is appropriate to complement industry efforts or to assure timely development.

Minimal—Little or no Federal involvement is warranted because industry efforts are likely to be adequate, or enough Federal/private R&D has been carried out to indicate that commercial viability is limited.

We re-examined the conservation and solar energy R&D in this report, and I would like, very briefly, to give you the results of this rating. We thought that there was a primary Federal role in R&D in biomass and building and community systems. A complementary Federal role in solar power technology—including photovoltaics and solar thermal—heat engines and heat recovery, industrial conservation, solar applications for buildings, and multisector conservation. There was a minimal Federal role for solar power technology—including wind, alcohol fuels, solar applications for industry, and transportation conservation.

I want to be absolutely clear that these are not priority or funding recommendations, only comments about the appropriate Federal role.

Thus, while the appropriateness of the Federal role is a necessary condition for justifying Federal energy R&D support, it is not sufficient. Because the report that will be issued next month only considers this one criterion, it will contain no specific funding recommendations and should not be interpreted as establishing energy R&D funding priorities.

For the private sector, for the reasons that I have noted, it often cannot provide sufficient support for any projects that meet the criteria justifying a Federal role.

In several cases, as we noted in the testimony that you will hear, such as the building industry, there is little ability or incentive to conduct R&D. The Department of Energy in making decisions on which conservation and improved end-use technology to support should take care to carefully analyze the sector of the economy that is involved, rather than relying on generalizations which are frequently inaccurate in specific cases.

By way of introduction, Mr. Chairman, Victoria Tschinkel who was the chairperson of our solar R&D panel, is the secretary of the Department of Environmental Regulation of the State of Florida, and has a distinguished career in environmental affairs. Her panel's excellent report on solar R&D spans an intractable range of subjects carried out in an impossibly short amount of time.

Mr. Grant Thompson, the chairman of the conservation panel is presently a senior associate at the Conservation Foundation, is the author of several important books on conservation, and a lawyer by training. The conservation report was an equally difficult task, but was expertly crafted and achieved an unusual degree of unanimity in an area where there are almost as many differing viewpoints as there are conservation technologies. Both Vicki and Grant are senior members of ERAB and we certainly appreciate their efforts and those of their panels in preparing these reports.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Bennett follows:]

STATEMENT OF IVAN BENNETT, BEFORE THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE, SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS, MARCH 9, 1983, 9:30 A.M.

MR./MADAM CHAIRMAN AND MEMBERS:

It is a pleasure and an honor for me to appear before the subcommittee on energy development and applications of the House Science and Technology Committee to discuss the findings and recommendations of the Energy Research Advisory Board reports on Solar R&D and Conservation. Mr. Louis H. Roddis, Jr., Chairman of the Board, regrets that he could not be present today. He asked me to meet with you to represent the Board and introduce the Chairpersons of the two ERAB reports that are the subject of these hearings today.

I am accompanied today by Victoria Tschinkel, chairwoman of the Solar R&D Panel and Grant Thompson, Chairman of the Conservation Panel, who will be presenting the findings and recommendatons of their respective reports to you. Also, we have with us Dr Mr. Thomas Kuehn, Executive Director of the Energy Research Advisory Board and two members of his staff who served as Secretaries to the Panels, Mr. William Woodard and Ms. Mary Gant.

We have had the honor to testify before this Subcommittee on two previous ERAB reports on R&D priorities and the DOE Multiprogram National Labs, so most of you are already familiar with the role of the Board. However, for those members unfamiliar with the Board, I should point out that the Board (ERAB) is an independent Advisory Committee established by DOE in 1978 and chartered under the Federal Advisory

Committee Act. It is the highest level science and technology advisory committee in DOE, reporting to the Secretary of Energy. Members are distinguished private citizens drawn from industry, universities, public interest groups and State and local Government.

Of course, the Board's role is ADVISORY ONLY and has no direct role in policy making. Conversely, I must also point out that neither ERAB nor myself represent the view of the Department. When speaking about the solar and conservation reports, we are speaking only for ERAB.

Both the Solar R&D and Conservation Reports were requested by the Deputy Secretary of Energy and were prepared by two outstanding ERAB panels over the course of the past year. The Solar Panel was requested to address four broad questions:

1. What specific research objectives should be supported by the Federal Government in each solar technology?

2. What is the present ability and incentive of industry to assume leadership for continued solar development?

3. What mechanisms may be needed to ensure an efficient transfer of solar technology developed by government to the private sector?

4. What is the appropriate Federal role with respect to each solar technology?

The report addresses each of these questions in turn, but let me focus my comments on the last question on the Federal role which really lies at the heart of the issue. Our assumptions about the appropriate Federal role will affect how these other questions will be answered.

In this regard, the solar report concluded that the primary Federal roles in solar R&D should be in support of basic and applied research, high-risk, high-payoff technology development and other necessary research for which there are insufficient market incentives. The Federal Government should also move strongly to transfer technology to the private sector for near-commercial technologies. It was also found that large demonstration and commercialization projects cannot be justified for Federal funding under current economic conditions and that these should be pursued by the private sector.

I will say more about the Federal role in specific solar R&D programs in a moment, but now I want to turn to the charge of the Conservation Panel.

The Deputy Secretary asked ERAB to address several items:

- Research and development activities in energy conservation that should be pursued by the Federal Government;

- The Federal Government's capability as a consumer of energy to conduct R&D in an effort to improve its own use of conservation technologies;

- Institutional restraints and market structures that prevent energy prices from calling forth an appropriate marketplace response in efficiency improvements; and,

- How the ability and incentive of the various sectors of our economy to conduct effective conservation research both on manufacturing processes and final products can be improved.

Again the Panel's report addresses each of these questions in depth, but I want to only point out that in considering the appropriate Federal role in conservation R&D the Panel's findings were similar in several respects to those of the solar report. Among the several findings and recommendations of this report is the need for Federal Government funding of those promising long-term, high-risk, potentially high-payoff conservation technologies that the private sector cannot support. Many energy conservation projects examined by the Panel satisfy the Department of Energy's criteria of long-term, high-risk, high payoff, and generic for Federal funding. In applying these criteria, however, the Department must consider the unique characteristics of the sector involved. In addition, the report points out that the Federal Government has been ineffective in managing its own consumption of energy. Top level government managers have not been effective in implementing known conservation technologies.

So you can see that in both the solar and conservation report the question of the Federal role is very important. But how do these R&D programs stack up against other R&D areas.

Because the Federal role question is central to all of the Board's recent studies, we recently undertook a special study, drafted by several ERAB members and chaired by William McCormick, to synthesize our views on this issue. Our report entitled "The Federal Role in Energy R&D" was submitted ot the Secretary of Energy on February 25, 1983 and will be published by late next month.

The origins of this effort actually date back to the Energy Research Advisory Board report on "Federal Energy R&D Priorities" in November 1981.

In that study, seven criteria were utilized in assessing energy program priorities. One of the criteria, not rigorously applied to each individual program, was whether or not a Federal role was appropriate. Because of this, and the later realization that the determination of the proper Federal role has been a key factor in every study the Board has undertaken, lead to this recent examination of this important criterion in more detail.

As noted in the report, there are wide differences between industries, and even within some industries, in ability and incentives to carry out R&D. As a result, useful generalizations are not possible, and decisions on the appropriate Federal role must carefully consider the characteristics of the industry, and sometimes the specific segment of an industry, that is involved.

In order to put our reports and recommendations in context, the solar and conservation programs were re-examined in this Federal role report relative to all other energy technology programs. Each energy technology program was evaluated with regard to several Federal role subcriteria including:

1. The current and expected future scope and amount of private-sector funding relative to requirements for an orderly R&D program.

2. Amount of development time to first commercial payoff.

3. Degree of risk of R&D to private sector development including:
    a. Technical risk--that the end-product cannot be developed.
    b. Market risk--that the end product will not attract customers at a price which would be profitable.

c. Policy (governmental) risk--that policy, or the possibility of policy changes, will make investment in R&D unattractive.

4. Need for Federal energy R&D involvement to support regulatory, environmental, or policy responsibilities.

An overall assessment of the appropriateness of a Federal role in support of each of the R&D programs is then done, sorting each program into three categories:

- Primary--The Federal Government should be the primary source of support because the industry participation is likely to be small, or the R&D is required to meet the Federal Government's regulatory or policy responsibilities.

- Complementary--Some Federal role is appropriate to complement industry efforts or to assure timely development.

- Minimal--Little or no Federal involvement is warranted because industry efforts are likely to be adequate, or enough Federal/private R&D has been carried out to indicate that commercial viability is limited.

The nature of the Federal role will vary with, among other factors, the state of development of the technology. As a general matter, a primary Federal role is seen in basic research and the exploration of new phenomena. As a technology reaches process or product development and then full-scale demonstration, the private sector role should grow relative to that of the Federal government; the exact course of that change should reflect the risk that remains. In this regard, ERAB recommends to DOE that the following guidelines be applied:

- Beyond the basic or exploratory research phase, DOE should insist on a significant level of co-funding by the private sponsor to assure that the technology is truly viewed as deserving a private risk. This must be more than just a "token" private contribution. Projects should be judged by the willingness of the sponsor to put private R&D dollars at risk. This is a far more reliable criterion than the often quite inaccurate and unreliable "appraisals" commissioned by DOE or private sponsors to justify projects where many of the resulting economic estimates are suspect.

- To provide further incentive for industry R&D, DOE should allow the resulting information to remain proprietary with due regard to free rights for the government's own use and willingness of the private sponsor(s) to license others at reasonable rates.

- Whenever private co-funding is substantial, guidelines should be established which allow the private sector participant(s) to manage the project without interference from DOE. Unwillingness to do so has resulted in excessive costs and often very poor judgment regarding program selection and objectives.

Without going into detail the solar and conversation R&D programs were rated as follows:

Primary Federal Role:

- Biomass
- Building and Community systems

Complementary Federal Role:

- Solar Power Technology (photovoltaics and Solar Thermal)
- Heat Engines and Heat Recovery
- Industrial Conservation
- Solar Applications for Buildings
- Multi-Sector Conservation

Minimal Federal Role:

- Solar Power Technology (Wind, OTEC)
- Alcohol Fuels
- Solar Applications for Industry
- Transportation Conservation

Let me point out to be absolutely clear, these are NOT priority or funding recommendations, only comments about the appropriate Federal role. Other criteria must be used to determine the relative funding priorities. In assessing program priorities in its 1981 report, ERAB employed seven specific criteria, including whether or not a Federal role in a given R&D program area was appropriate. Other criteria that were used in the 1981 report to establish program priorities included: technology potential; urgency of R&D; economic potential; benefits vs. R&D costs; contribution to energy/national security; and health and safety impacts. Thus, while the appropriateness of the Federal role is a necessary condition for justifying Federal energy R&D support, it is not sufficient. Because the present report only considers this one criterion, it contains no specific funding recommendations and should not be interpreted as establishing energy R&D funding priorities.

To give you a better idea of how these criteria were applied and the rationale behind the Federal role assigned, let me give you a few examples from the report:

Solar Power Technology

With respect to photovoltaic energy, the private sector is engaged in very substantial efforts on photovoltaic materials and modules, aimed at providing high efficiency, low cost P.V. modules. However, a Federal role was found to be important to complement the private efforts, spanning basic research on solar radiation and on improved photovoltaic materials, module development and testing and, when warranted, testing of entire systems of sufficient size to demonstrate the performance and economics of this type of system.

Solar thermal systems have reached the stage that a more limtied Federal R&D role is appropriate. Apart from completing the testing of plants now in existence and refocusing efforts on high technology parabolic dish engine technology, an appropriate Federal role would inlcude exploration of novel concepts and supporting R&D. The Federal role here is complementary.

Because the potential payoff is quite limited, as well as uncertain, there is little justification for other than a minimal Federal role in ocean thermal electric conversion (OTEC).

The wind industry has both the incentive and the ability to carry out R&D needed for improved wind machines. The Federal role is minimal, but is necessary in completing and testing existing machines and in providing the technological basis for scaling up to the 5-7 MW size.

Biomass Energy

In this highly diversified industry a small amount of funds has been invested in both biomass resource production and conversion technologies. The private sector funding is assessed to be medium relative to the required needs.

DOE R&D should be focused on basic studies of biomass resource production and conversion technologies. High research priority should be given to forests for biomass resource production, because nearly half of all potential biomass will probably come from this resource. Conversion technology research is of secondary importance and should emphasize liquid and gas fuel conversions.

Because forest biomass resource production enhancement deals with basic research, the Federal research role is rated as primary. The conversion technology research, such as discovering microorganisms that will convery lignocellulosic material to alcohols, also depends upon basic studies and the Federal role in this area is primary.

Alcohol Fuels

The primary alcohol fuel being produced is ethanol from corn grain. While the investment by the private sector in R&D appears to be relatively small, this is a fairly well established technology, although the process would not be economically competitive in the absence of tax subsidies. Cellulosic biomass is more abundant and could be a cheaper base for ethanol production, but this process requires development. The required Federal role investment is therefore rated as minimal, except for some basic research on conversion processes.

Heat Engines and Heat Recovery

The goal of this program is to provide advanced stationary power systems that can utilize noncritical fuels such as coal, coal-derived liquids and gases, residual petroleum and waste heat. DOE has proposed to phase out this work entirely, while the ERAB report on priorities recommended continued funding for selected subjects. It is not known how much of this work will be continued by private industry, or how rapidly but commercialization will be considerably slower (or delayed indefinitely) than would have been the case with Federal funding. One must also recognize the very high cost of developing full-size mschines for operation at the hoped-for high temperatures. This constitutes a financial risk beyond the reach of most manufacturers. Co-funding may again be the very best way to assure proper selection of R&D projects, but until success is assured, the Federal role remains complementary.

Building and Community Systems

The potential dollar benefits of relatively small improvements in the energy efficiency of building envelopes, HVAC systems, appliances, and lighting are substantial, as would be the savings in oil and natural gas. However, the building industry is dominated by small firms, even the largest of which are incapable of carrying out R&D at the levels required. Also, there is little incentive to support R&D, as many of the resulting improved techniques, materials, etc., would be difficult to patent and therefore provide no competitive advantages to the developer. Further, private firms have little incentive to conduct R&D on the potential human health and safety risks of construction materials and techniques, which may be significant (e.g., indoor pollution resulting from reduced air infiltration and from urea formaldehyde insulation).

Therefore, due to a combination of the above-noted factors involving Building and Community Systems activities ERAB concluded that Federal support is necessary if the benefits are to be achieved in a reasonable time period. A primary Federal role is indicated for R&D supporting the building industry.

Industrial Conservation

The industrial sector is extremely diverse, and it is difficult to make any useful generalizations about it. One cannot even assume that industry will always respond efficiently to prices, or that it has the technical ability to develop energy saving processes or products. The evidence is clear, however, that while a few industries have done very well in energy conservation, others have failed to invest in even the simplest conservation measures with proven high payoffs.

Of the heavy eneryg-consuming industries, only the petroleum refining and chemical industries do a significant amount of R&D, including R&D on energy conservation, and certain large firms in other industries support conservation R&D programs. It is not apparent, however, where funding will come from for major process improvements which are assumed to be necessary for many of the U.S. industries composed of small entities. This being the case, a Federal role is envisioned to undertake exploratory R&D in generic high-risk process improvements and other energy-conserving areas. However, to assure a well-directed program with a good chance for commercial accpetance, private industry will have to tkae the lead with a supporting, complementary, Federal role.

Multi-Sector Conservation

The R&D supported under energy conservation and utilization technology programs is generally of a longer-term nature, applicable to many end-use sectors and ultimately promising high payoffs. A complementary Federal role is justified because either the industrial structure to support the R&D does not exist, or the benefits would be widespread and not profitable to the industrial sponsor.

Solar Applications for Buildings

Tax incentives are available for solar heating. The private sector has undertaken commercial activities, including R&D, and a minimal Federal role is adequate. There are appropriate areas for a Federal role in R&D in solar cooling, and passive and hybrid solar. As noted under Buildings and Community Systems, the building industry is highly fragmented, and not capable of carrying out significant R&D.

We also suggested that the DOE Buildings and Community Systems conservation program should be combined with the Active and Passive Solar Applications for Buildings program. This would allow a much more integrated, coordinated and effective effort toward achieving the overall goal.

A photovoltaics industry exists, although the product is not competitive except in small, specialized markets. Significant possibilities for increasing efficiency lie with other solar photovoltaic technologies, where much R&D remains to be done. Specific Federal R&D recommendations iwll be found in the ERAB Solar R&D Report. The Federal role is complementary.

Solar Applications for Industry

This program is being reoriented by DOE to eliminate development and demonstration work on contral receivers and distributed receivers and to concentrate on basic research to expand the technology base for solar thermal energy.

The Federal Government has expended considerable funds on the development and demonstration of central receiver systems. These systems are unlikely to be commercialized unless the Government follows through by funding the operation of major demonstration projects to collect, evaluate, and disseminate systems test data on plant performance and operating characterictics. Industry will be unwilling to invest in commercial plants until such data is collected and made available. Therefore, a Federal role is essential to ensure transfer of the technology. There is also a Federal role in conducting generic research to develop a better technology base for solar thermal technologies, including reflective and ceramic materials, system level controls, and concentrator designs. Overall, the appropriate Federal role in this area is minimal.

In summary, the private sector, for reasons noted above, does not or cannot provide sufficient support for many projects that meet the criteria justifying a Federal role. In several cases, such as the building industry, there is little ability or incentive to conduct R&D. The Department of Energy, in making decisions on which conservation and improved end-use technologies to support, should take care to carefully analyze the sector of the economy that is involved rather than relying on generalizations which are frequently inaccurate in specific cases.

Finally, let me point out that in neither of these reports did we attempt to make specific recommendations on funding levels. This is left for the Department and Congress to decide as is appropriate. However, in both reports we assumed levels of support at about equal to the 1982 appropriations as a base-line that seemed reasonable and prudent for continued progress in the technology base. These levels represent a substantial decrease over prior years which we also viewed as an appropriate withdrawal from costly, large scale demonstrations given present fiscal problems faced by the nation.

I personnally think that events since these reports were written support our recommendations for moderation. The so called "oil glut" will certainly slow both the commercial introduction of solar technology and the nation's overall conservation efforts with the availability of cheaper oil on the world market. But this situation is only transitory given the finite nature of the petroleum resource and the geopolitical instability of the world today. As a nation we would be wise to continue to develop our domestic and renewable energy options at a reasonable pace because we will most certainly need to call on these options one day, perhaps sooner than we might like. The Solar and Conservation Panels sought a concensus on the level of effort required to sustain progress at a cost that was affordable to the nation in these difficult times. I hope these reports will prove useful to DOE and the Congress in determining those R&D programs that merit continued Federal support.

I hope I didn't steal all of the thunder from your next ERAB witnesses, but I don't think this is the case. By way of introduction, Victoria Tschinkel is presently Secretary of the Department of Environmental Regulation of the State of Florida and has had a distinguished career in environmental affairs. She was an honest working biologist before that, and now has mastered the art of science advice as evidenced by her Panel's excellent report on solar R&D which spanned an intractable range of subjects in an impossibly short amount of time. Grant Thompson is presently a Senior Associate at the Conservation Foundation, noted author of several important books on conservation, and a lawyer by training.

The Conservation Report was an equally difficult task, but was expertly crafted and achieved an unusual degree of unanimity in an area where there are almost as many differing viewpoints as there are conservation technologies. Both Vicki and Grant are senior members of ERAB and we certainly appreciated their efforts and those of their Panels in preparing these reports.

Resume

IVAN L. BENNETT, JR.

BORN

Washington, DC, March 4, 1922

MARRIED

Martha Rhodes, 1944; 4 children

EDUCATION

Emory University, AB 1943; MD 1946
University of South Carolina, Honorary LHD 1981
Post Graduate Residency Training:
  Emory University
  Duke University
  Johns Hopkins University
  Diplomate in Internal Medicine, 1954

MILITARY SERVICE

Lt. jg, MC, USNR, US Naval Medical Research Institute, Bethesda, MD 1947-49

POSITIONS HELD

Assistant Professor of Internal Medicine, Yale, 1952-54
Associate Professor of Medicine; Professor of Medicine; Professor of Pathology, Johns Hopkins University, 1954-69
  Pathologist-in-chief, Johns Hopkins University, 1958-69
Deputy Director and Acting Director, OSTP, Office of the President 1966-69
Vice President and Executive Vice President for Health Affairs, New York University, 1969-82; Dean, NYU School of Medicine 1970-1982; Acting President, NYU 1979-82
Professor of Medicine, NYU 1970-Present

MEMBERSHIP

Approximately 50 professional and honorary societies
President, Science Advisory Committee
  Member 1966-70; consultant-at-large 1970-72
National Board of Medical Examiners 1966-68
UN Secretary General's Study Group on Chemical and Biological Warfare 1969
Chairman of the US-Japan Cooperative Medical Science Program 1972
Charter member, Institute of Medicine
Life Sciences Advisory Committee of NASA 1971-73
President's Committee on National Medal of Science 1970-74
Consultant, NSC 1973-77
Director's Advisory Committee NIH 1978-81
Chairman, Association of American Medical Colleges 1976
Defense Science Board, DOD 1972-present
Vice Chairman Energy Research Advisory Board DOE 1980-present

AUTHOR

200 scientific and technical papers
"Principles of Internal Medicine" Editions 3, 4, 5, 6

Mr. FUQUA. Thank you very much.

Grant, we'll try not to hold that against you, being an attorney.

Vicki, we would be pleased to hear from you now.

STATEMENT OF VICTORIA TSCHINKEL, CHAIRMAN, ENERGY RESEARCH ADVISORY BOARD, SOLAR R&D PANEL

Ms. TSCHINKEL. Thank you, Mr. Chairman.

I'm Vicki Tschinkel, the secretary of the Florida Department of Environmental Regulation. I'm a member of the Energy Research Advisory Board. Last year I chaired the solar energy panel for ERAB.

The charge for our panel originally emanated from you, Mr. Chairman, and Deputy Secretary Ken Davis referred that to ERAB. I hope the report has been of some use to you and your staff in their deliberations.

The panel was established and met in May, and we only had between May and September to complete our work. Our report was approved by ERAB on September 9. The reason for the rushed-up schedule was a request by the Department to get our information to them so that it could still be of some value to them in budget preparation for fiscal year 1984. That was the reason for the rush.

We had approximately 7 days of briefings by 70 individuals so it was a bit of a herculean task. We had several staff reports that also were prepared for our work. I would say that our members tried very hard, although we came from many sectors of the community, to be fair and objective and come up with a consensus report. We had seven regular ERAB members on the panel, including David Pimentel, from Cornell University, whom I think you know. In addition, there were several other members of the panel who are also familiar to you, I believe, Roger Little from Spire Corp., John Yellot from the University of Arizona, Don Berkey from GE, and Larry Papay from Southern California Edison. I believe you probably know all of them.

We covered seven solar areas—but did not attempt to hit everything, of course. We addressed photochemistry and basic research, photovoltaics, solar thermal, wind, OTEC, biomass, and buildings. We also have a section related to institutional problems, for example tax credits. We tried to take a pragmatic approach, given the real world as it stands right now, and assumed budget levels of approximately the 1982 appropriated budget for our deliberations.

We recognized the present view that long-range, high-risk research ought to be supported by the Federal Government and tried to craft a report around those policy determinations. The report examined each one of these technologies in several areas. We looked at critical R&D as using each technology, the state of the industry as it stands both financially and technically, the problems in transferring R&D from Government to industry, and tried to divide up a research agenda appropriate for industry and the private sector on the one hand, and the Government on the other.

Let me go over several general findings, and then just a few findings related to each technology. First of all, ERAB found that the solar energy technologies represented collectively a highly promising energy option. I don't think we should forget that in solar energy we have proven technical feasibility, and a secure long-term renewable resource base. Obviously, there are restrictions to it—geographical, temporal, problem with diurnal flex—of course—diffuse source of energy. All these things need to be looked at as the challenge of doing research in the solar field.

We also wanted to commend the solar industry and the Government for the significant progress that has been made in the past 10 years with a significant amount of Government funding. We feel this can continue with a very careful and defined Federal program with a very well understood definition of what the appropriate Federal and private sector roles are to be.

We also found that the solar industry is in a relatively precarious state, as compared to other energy and other energy sources and more traditional industrial basis. To give you some reasons for that; changing tax laws; the fact that there is a high capital investment. The uncertain energy market is obviously going to hit a field where there is some perception that some of these sources may not be as reliable as others. The uncertainty in the Federal role has been a problem for the industry, and of course, finally, we have significant foreign competition coming into the solar energy market.

We made a recommendation, which I think is true for almost all the energy sources, that it is very important to have more consistent Federal programs. We recommended a 2-year rolling appropriation process. We need continuity, we need relative stability, and we need gradual change. We have very talented people working in this field. A lot of equipment has been bought. Not only does this uncertainty disrupt the program in Government, but there's also a problem with industry when uncertainty exists and unanticipated costs exists. If they are to pick up a greater burden they need to know exactly what it is going to be going on in the future.

We found in general, given the current budgetary situation, that major new demonstration projects are not warranted at this time. However, we certainly see a place for cost-shared engineering facilities as that is warranted.

We think there should be vigorous support for basic research on all areas—ranging from photochemistry to materials. We also feel that we ought to, probably, look beyond the Office of Energy Research for this basic research into the Assistant Secretary's program.

We also felt that technology transfers are particularly important at this juncture when we are looking at transferring more and more responsibility to private industry.

Now, with your permission, I would like to make just a few comments about each of the technologies.

First of all, in photovoltaics, obviously, I think there you have the perfect fit for the administration's policy emphasizing long-range high-risk, high-payoff research. We recommended, though, a very broad continuation in cell development for either cheap or efficient cells, looking at both kinds. We recommended expenditures on concentrators. We recommended that it might be appropriate on certain occasions to look at development of processing equipment. We thought that, in general, the balance of system costs could be picked up by the industry, and we recommended discontinuation of the SMUD program.

We were impressed in the solar thermal program that there does seem to be rapid transfer to private industry. Nevertheless, there do continue to be some important things for the Government to do. First of all, we need to finish the Solar I project and be sure all the technology transfer that we can get out of it is gotten out of it. We have a heavy investment in it.

With the very impressive efficiencies of the parabolic dish, it seems to me we ought to be spending considerably more and shifting effort to still increase the efficiency of this, and try to increase the life of the technology, and to decrease the cost of operating it. There are a number of options one could emphasize in this program. We seem to need some parabolic dish-engine modules that could be cost-shared with industry, and it seems highly promising to us.

We recommended that the hemispherical bowl be discontinued. On parabolic troughs, we recommended continuation of operational testing, to get some long-term data that would help stabilize the industry. In solar ponds we recommended only a monitoring program at this time, which could be stepped up later.

On the wind program the top priority for us would be to continue to gather data, analyze and publish data on the MOD-2 and other existing machines. We need greatly advanced analytical capabilities with respect to the advanced machines. If the budget permitted, that is if we saw a budget about the fiscal year 1982 appropriated level, we felt that the MOD-5 ought to be completed because that is going to be, very likely, the most widely used machine. It is going to have the largest significance for energy in this country in the wind program.

We also recommended that the Rocky Flats testing program be continued on a cost-sharing basis by industry, and that the work on the small wind machines, except for the analytical techniques that I mentioned to you, be discontinued by about 1985.

With respect to OTEC, we saw that it was probably appropriate that there be no further demonstration projects at this time. The preliminary designs that are being done at this time ought to be continued. However, we did recommend a continued effort in modest technology base research .

In biomass we saw some organizational problems in the biomass program at DOE. It needs a sharpened focus. We saw the need for a strong emphasis in making progress in basic biological energy research related to expanding the resource base. That was going to be, we felt, the most important area for research as opposed to secondary emphasis on conversion. We saw a need in emphasizing the resource base—looking at chemical screening of plants—of looking at improved agronomy in the country—basic research in photosynthesis and photochemistry and metabolism of plants.

We also saw that this was an area where environmental impact needed to be heavily emphasized; soil erosion, nutrients, and additional work on the food/fiber energy conflict.

In the buildings area I think we agreed with most reports that have looked in this area. First of all, we felt that the program inside DOE related to solar and related to conservation needed to be consolidated. It is a fairly artificial distinction, and probably does not serve the program very well. The industry is fragmented, as we all know, and we recommended that the industry be induced into forming a Buildings Energy Research Institute with the Department taking a major role in its development. There still is an important amount of actual research work to be done in this area, related particularly to materials and to understanding building thermal systems. There is also an important role here for DOE and technology transfer. An awful lot of work has been done, and it needs to be put in a language that builders can understand—data has got to be kept up to date.

Finally, I want to make a comment on some other institutional problems, particularly related to taxes. There was no question in our mind that it is essential to the solar programs of this country to retain business and residential energy tax credits to 1990. We believe that there ought to be a well thought out program of phase-outs, commencing after 1986, so industry can plan for them. I would also like to emphasize that PURPA was considered very important to the solar programs. However, on the other hand, we did not see a particular rationale to continue the alcohol fuels exemption.

I would like to mention that the Department, and the national laboratories, and other laboratories we visited were extremely cooperative to all of us and were very anxious to give us all the information—and more—that we requested.

I believe that many of the recommendations were followed by the Department, and I guess a few of them were not. As an advisory body we did appreciate very much the opportunity to work on the subject and will be glad to answer any questions—or try.

[The prepared statement of Ms. Tschinkel follows:]

STATEMENT OF VICTORIA TSCHINKEL BEFORE THE HOUSE SCIENCE AND TECHNOLOGY COMMITTEE, SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS, MARCH 9, 1983, 9:30 A.M.

MR./MADAM CHAIRMAN AND MEMBERS:

IT IS A PLEASURE FOR ME TO BE APPEAR BEFORE THE SUBCOMMITTEES ON ENERGY DEVELOPMENT AND APPLICATIONS AND ON ENERGY RESEARCH AND PRODUCTION TO DISCUSS THE FINDINGS AND RECOMMENDATIONS OF THE ENERGY RESEARCH ADVISORY BOARD REPORT ON SOLAR ENERGY RESEARCH AND DEVELOPMENT: FEDERAL AND PRIVATE SECTOR ROLES.

MY NAME IS VICTORIA TSCHINKEL AND I AM SECRETARY OF ENVIRONMENTAL REGULATION FOR THE STATE OF FLORIDA. LAST YEAR I SERVED AS CHAIRMAN OF THE SOLAR R&D PANEL OF THE ENERGY RESEARCH ADVISORY BOARD.

RESPONDING TO AN INQUIRY FROM CONGRESSMAN FUQUA REGARDING THE DEPARTMENT OF ENERGY'S SOLAR R&D PROGRAM, LAST MARCH THE DEPUTY SECRETARY REQUESTED THAT THE ERAB CONDUCT A STUDY DEFINING THE APPROPRIATE FEDERAL ROLE IN SOLAR ENERGY AND DEVELOPMENT AND TO IDENTIFY FOR FEDERAL SUPPORT LONG-TERM, HIGH-RISK, POTENTIALLY HIGH-PAYOFF R&D AND TECHNOLOGY TRANSFER ACTIVITIES. THE CHAIRMAN OF THE BOARD, LOUIS H. RODDIS, APPOINTED ME AS CHAIRMAN, AND TWELVE OTHER INDIVIDUALS TO THE SOLAR R&D PANEL, WHICH WAS TO SURVEY THE FIELD AND SUBMIT A DRAFT REPORT TO THE FULL BOARD BY SEPTEMBER, 1982.

IT WAS A REAL PRIVILEGE FOR ME TO CHAIR A GROUP WHICH WAS DETERMINED TO ARRIVE AT FAIR AND OBJECTIVE CONCLUSIONS AND RECOMMENDATIONS. OUR PANEL REPRESENTED A BALANCED DIVERSITY OF VIEWPOINTS. EVEN MORE IMPORTANT, IT WAS COMPOSED OF INDIVIDUALS WHO WERE PREPARED TO AND DID DEVOTE A GREAT DEAL OF PERSONAL TIME AND EFFORT TOWARD FULFILLING THE CHARGE TO THE BOARD BY THE DEPUTY SECRETARY OF ENERGY. THIS WAS A DISTINGUISHED GROUP AND THE BOARD VERY MUCH APPRECIATED THEIR EFFORTS. AS IS CUSTOMARY, THEY SERVED WITHOUT PAY. THE MEMBERSHIP OF THE PANEL IS ON PAGE iii OF THE REPORT, OF WHICH YOU HAVE COPIES. DURING THE COURSE OF ITS DELIBERATIONS THE PANEL ADDRESSED FOUR SPECIFIC QUESTIONS FOR EACH SOLAR TECHNOLOGY, AS REQUESTED BY THE DEPUTY SECRETARY:

1. IN EACH SOLAR TECHNOLOGY, WHAT SPECIFIC RESEARCH OBJECTIVES SHOULD BE SUPPORTED BY THE FEDERAL GOVERNMENT?

2. WHAT IS THE PRESENT ABILITY AND INCENTIVE OF INDUSTRY TO ASSUME LEADERSHIP FOR CONTINUED SOLAR DEVELOPMENT?
3. WHAT MECHANISMS MAY BE NEEDED TO ENSURE AN EFFICIENT TRANSFER OF SOLAR TECHNOLOGY DEVELOPED BY GOVERNMENT TO THE PRIVATE SECTOR?, and,
4. WHAT IS THE APPROPRIATE FEDERAL ROLE WITH RESPECT TO EACH SOLAR TECHNOLOGY?

BEGINNING LAST MAY THE PANEL MET WITH REPRESENTATIVES FROM INDUSTRY, UNIVERSITIES, GOVERNMENT LABORATORIES, PRIVATE RESEARCH ORGANIZATIONS, AND THE DEPARTMENT OF ENERGY. ALL OF OUR MEETINGS WERE OPEN TO THE PUBLIC AND ANY INTERESTED PERSONS WERE INVITED TO PRESENT THEIR VIEWS. THE PANEL ALSO MET AT THE SOLAR ENERGY RESEARCH INSTITUTE IN GOLDEN, COLORADO, AND AT SANDIA LABORATORIES IN ALBUQUERQUE, NEW MEXICO. THE AGENDAS FOR THESE MEETINGS ARE CONTAINED IN APPENDIX C OF THE REPORT. THE PANEL'S DRAFT WAS SUBMITTED TO THE FULL BOARD LAST SEPTEMBER AND WAS CONSIDERED AT THAT TIME AT THE BOARD'S REGULAR QUARTERLY MEETING. IT WAS APPROVED BY THE BOARD AND TRANSMITTED TO THE DEPARTMENT LAST OCTOBER.

THE PANEL EXAMINED A BROAD RANGE OF R&D OPTIONS IN EACH OF SEVEN SOLAR TECHNOLOGIES INCLUDING: PHOTOCHEMISTRY AND BASIC RESEARCH, PHOTOVOLTAICS, THERMAL, WIND, OCEAN THERMAL ENERGY CONVERSION, BIOMASS, AND BUILDINGS TECHNOLOGIES. THE PANEL FOUND A WIDE

SPECTRUM OF PROMISE AND POTENTIAL. SOME TECHNOLOGIES ARE COMMERCIALLY AVAILABLE OR READY FOR COMMERCIALIZATION AND DO NOT REQUIRE FEDERAL SUPPORT; SOME SHOW LITTLE PROMISE, AND SHOULD NOT CONTINUE TO RECEIVE FEDERAL SUPPORT. OVERALL, THE PANEL THOUGHT ITS FINDINGS AND RECOMMENDATIONS CONSTITUTED A WORTHWHILE FEDERAL PROGRAM SUFFICIENT TO PROVIDE THE LONG-TERM SCIENTIFIC AND TECHNICAL BASE NEEDED TO GRADUALLY ADVANCE SOLAR TECHNOLOGIES. TABLE A ON PAGE 5 OF THE REPORT PROVIDES A SUCCINCT CHART OF SOLAR R&D PRIORITIES AS WE VIEWED THEM. ON PAGES 2 THROUGH 5 YOU WILL FIND OUR GENERAL AND SPECIFIC FINDINGS AND RECOMMENDATIONS.

WHILE I DO NOT INTEND TO GO OVER EACH OF THESE RECOMMENDATIONS IN DETAIL, I WOULD LIKE TO HIGHLIGHT SOME OF THEM. THE COMMITTEE WILL BE HEARING LATER FROM REPRESENTATIVES OF THE DEPARTMENT ON THEIR IMPLEMENTATION OF THE REPORT'S SPECIFIC RECOMMENDATIONS, AND THE BOARD WILL BE RECEIVING A BRIEFING ON THIS MATTER AT ITS MAY MEETING. THEREFORE, I AM NOT ABLE TO COMMENT ON THIS SUBJECT AT THIS TIME.

IN GENERAL IT WAS THE BOARD'S VIEW THAT SOLAR ENERGY REPRESENTS A HIGHLY PROMISING ENERGY OPTION FOR THE NATION, AND THAT SIGNIFICANT PROGRESS HAS BEEN MADE OVER THE PAST 10 YEARS IN THE VARIOUS SOLAR TECHNOLOGIES. HOWEVER, SINCE IT IS A RELATIVELY NEW FIELD IT IN MANY WAYS IS IN A PRECARIOUS POSITION RELATIVE TO CONVENTIONAL ENERGY TECHNOLOGIES AND OLDER, MORE FIRMLY ESTABLISHED TECHNOLOGIES. IN ADDITION TO THE TECHNICAL RISKS ASSOCIATED WITH RELATIVELY NEW TECHNOLOGIES, THE EMERGING SOLAR INDUSTRY HAS TO CONTEND WITH TODAY'S

ECONOMIC CONDITIONS, INCLUDING THE HIGH COST OF CAPITAL AND FLUCTUATING ENERGY DEMAND AND PRICES, AS WELL AS UNCERTAIN FEDERAL TAX AND REGULATORY POLICIES -- ALL OF WHICH SERVE TO INCREASE THE PERCEPTION OF RISK AND TO DISCOURAGE INVESTMENT. FOR THIS REASON WE RECOMMENDED A MORE CONSISTENT, AND PREDICTABLE FUNDING POLICY, INCLUDING SUPPORT FOR ROLLING TWO-YEAR APPROPRIATIONS BY CONGRESS FOR SOLAR R&D, WITH CARRYOVER FUNDING. WE ALSO RECOMMENDED THAT THE BUSINESS AND RESIDENTIAL ENERGY TAX CREDITS BE EXTENDED TO 1990, WITH GRADUAL PHASEDOWN BEGINNING AFTER 1986. THIS WOULD HELP STIMULATE PRIVATE INVESTMENT IN THE SOLAR INDUSTRY BY BALANCING EXISTING SUBSIDIES FOR OTHER ENERGY SOURCES. FINALLY, WE CONCLUDED THAT THE PUBLIC UTILITIES REGULATORY POLICY ACT, SINCE IT HAD PLAYED A SIGNIFICANT ROLE IN ENCOURAGING THE USE OF SMALL SOLAR ELECTRIC TECHNOLOGIES, IS ESSENTIAL TO THE SURVIVABILITY OF THE INDUSTRY, AT LEAST IN THE NEAR TERM.

THE PANEL ALSO THOUGHT THAT SUPPORT FOR BASIC AND APPLIED RESEARCH AND HIGH-RISK, POTENTIALLY HIGH-PAYOFF TECHNOLOGY DEVELOPMENT WERE IMPORTANT FEDERAL ROLES. HOWEVER, IN VIEW OF DOE'S STATED POLICY, THE BOARD CONCLUDED THAT DEMONSTRATION AND COMMERCIALIZATION PROJECTS REQUIRING LARGE CAPITAL OUTLAYS COULD NOT BE JUSTIFIED FOR FEDERAL FUNDING UNDER PRESENT BUDGETARY CONDITIONS. WE DID CONSIDER THAT SOME ENGINEERING DEVELOPMENT PROJECTS, SUCH AS SMALL SCALE PILOT PLANTS, COULD BE JUSTIFIED WHERE THERE IS INDUSTRY COST SHARING.

SO MUCH FOR SOME OF OUR GENERAL OBSERVATIONS. IN SPECIFIC TECHNOLOGY AREAS OUR RECOMMENDATIONS COULD BE SUMMARIZED AS FOLLOWS.

BASIC RESEARCH

THE BOARD RECOMMENDED CONTINUED SUPPORT FOR RESEARCH IN PHOTOSYNTHESIS AND PHOTOCHEMISTRY, AND VIGOROUS SUPPORT FOR BASIC RESEARCH IN MATERIALS. ADDITIONALLY BASIC RESEARCH SHOULD BE FUNDED NOT ONLY THROUGH THE OFFICE OF ENERGY RESEARCH, BUT ADDITIONALLY BY THE ASSISTANT SECRETARY FOR CONSERVATION AND RENEWABLE ENERGY. IT WAS ALSO OUR VIEW THAT DOE SHOULD HAVE A LEAD ROLE IN SUPPORTING SOLAR RESEARCH AND EDUCATION AT UNIVERSITIES, AND THUS ASSURE THE CONTINUED AVAILABILITY OF EDUCATED SCIENTISTS AND ENGINEERS.

PHOTOVOLTAICS

PHOTOVOLTAICS RESEARCH IS AN IDEAL CANDIDATE FOR ADMINISTRATION SUPPORT SINCE IT CLEARLY REPRESENTS A LONG-TERM, HIGH-RISK TECHNOLOGY WITH THE POTENTIAL FOR HIGH PAYOFF. WE ASSIGNED THE HIGHEST PRIORITY TO RESEARCH ON SINGLE-JUNCTION CRYSTALLINE THIN FILMS, HIGH-EFFICIENCY CELLS, AMORPHOUS SILICON, AND INNOVATIVE CONCEPTS, SUCH AS ELECTROLYTIC CELLS, POLYMERS, AND NEW MATERIALS WITH THE POTENTIAL FOR MAJOR BREAKTHROUGHS. ON THE NEGATIVE SIDE, THE BOARD RECOMMENDED THAT SUPPORT FOR THE 1 MWe PHOTOVOLTAICS SACRAMENTO MUNICIPAL DISTRICT (SMUD) DEMONSTRATION BE DISCONTINUED.

SOLAR THERMAL

IN SOLAR THERMAL TECHNOLOGIES THE BOARD NOTED THAT THEY WERE RAPIDLY BECOMING READY FOR TRANSFER TO INDUSTRY, AND RECOMMENDED INCREASED EMPHASIS ON THE PARABOLIC DISH TECHNOLOGY DEVELOPMENT, DISCONTINUATION OF THE HEMISPHERICAL BOWL PROGRAM, AND FEDERAL

SUPPORT ONLY FOR OPERATIONAL TESTING OF PARABOLIC TROUGHS, SINCE THEY ARE NOW COMMERCIALLY AVAILABLE. WHILE THE BOARD WAS UNCERTAIN ABOUT THE PROSPECTS FOR SOLAR POND TECHNOLOGY, IT RECOMMENDED THE MAINTENANCE OF A SMALL TECHNICAL STAFF TO MONITOR PROGRESS IN THE FIELD.

WIND

THE BOARD ASSIGNED ITS HIGHEST PRIORITY TO SUPPORT FOR DATA GATHERING, ANALYSIS, AND PUBLICATION OF TEST RESULTS ON THE MOD-2 MACHINES AT GOLDENDALE, WASHINGTON. IT ALSO RECOMMENDED THAT DOE CONSIDER COST SHARING OF THE DATA ACCUMULATION AND ANALYSIS ON THE WTS-4 WIND MACHINE PURCHASED BY THE DEPARTMENT OF INTERIOR AND INSTALLED AT MEDICINE BOW, WYOMING. SINCE SMALL WIND MACHINES ARE COMMERCIALLY AVAILABLE THE BOARD RECOMMENDED THAT SUPPORT FOR DEMONSTRATION PROJECTS BE PHASED OUT AFTER 1985. THE BOARD ALSO RECOMMENDED COMPLETION OF THE MOD-5 DEVELOPMENT PROGRAM, BUT ONLY IF THE OVERALL SOLAR BUDGET REMAINED AT THE APPROXIMATELY THE FY'82 LEVEL.

OCEAN THERMAL ENERGY TECHNOLOGY (OTEC)

ALTHOUGH THE BOARD DID NOT ASSIGN OTEC A HIGH PRIORITY, AND RECOMMENDED THAT NO FURTHER DEMONSTRATIONS SHOULD BE FEDERALLY FUNDED, IT WAS OF THE VIEW THAT DOE SHOULD CONTINUE ITS INVOLVEMENT IN THE PRELIMINARY OTEC DESIGN PROGRAM, AND IN A MODEST TECHNOLOGY BASE EFFORT, SUCH AS RESEARCH ON THE SHORE AND SHELF COLD WATER

PIPE AND HEAT EXCHANGER, AS WELL AS SUPPORT FOR RESOURCE AND ENVIRONMENTAL ASSESSMENTS. THE BOARD ALSO THOUGHT THAT THE OTEC BUDGET SHOULD NOT BE ELIMINATED ENTIRELY.

BIOMASS

THE BOARD RECOMMENDED THAT THE BIOMASS ENERGY PROGRAM REQUIRED A SHARPER FOCUS WITH CLEAR OBJECTIVES, PRIORITIES, AND RESPONSIBILITIES. THERE SHOULD BE A STRONG BASIC PROGRAM IN BIOLOGICAL ENERGY RESEARCH, AND ALSO SUPPORT FOR BASIC RESEARCH IN EXPANDING THE RESOURCE BASE OF BOTH TERRESTRIAL AND AQUATIC PLANTS AND IN EXPANDING THE TECHNOLOGY BASE IN BIOLOGICAL AND THERMOCHEMICAL CONVERSION OF BIOMASS, ESPECIALLY LIGNOCELLULOSIC MATERIALS FROM FORESTS. THE BOARD ALSO ASSIGNED A HIGH PRIORITY TO SUPPORT FOR CONTINUED ENVIRONMENTAL IMPACT ASSESSMENTS.

BUILDINGS SOLAR ENERGY RESEARCH

ONE OF THE MOST DIFFICULT, BUT CERTAINLY ONE OF THE MOST CRUCIAL AREAS THE BOARD DELIBERATED OVER WAS IN THE BUILDINGS ENERGY RESEARCH FIELD. THE BOARD RECOMMENDED A HIGHER PRIORITY BE GIVEN TO BUILDINGS ENERGY PERFORMANCE TESTING AND DOCUMENTATION, AND TO RESEARCH IN MATERIALS WITH SELECTIVE THERMAL, OPTICAL, AND STRUCTURAL PROPERTIES, IN NEW SYSTEMS FOR HEATING AND COOLING, IN HEAT AND MASS TRANSFER, AND IN LIGHTING IN BUILDINGS. THE BOARD ALSO RECOMMENDED THAT DOE ESTABLISH A COMPREHENSIVE AND CONSOLIDATED BUILDINGS SOLAR ENERGY

RESEARCH PROGRAM. FINALLY THE BOARD RECOMMENDED THAT DOE INITIATE DISCUSSIONS WITH BUILDINGS TRADE ASSOCIATIONS TO PROMOTE THE FORMULATION OF A BUILDINGS SOLAR ENERGY RESEARCH INSTITUTE. THE DIVERSITY AND DIFFUSENESS OF THE BUILDINGS INDUSTRY, AS WELL AS THAT OF SOLAR EQUIPMENT SUPPLIERS, HAS PREVENTED THE INDUSTRY FROM ADEQUATELY CONDUCTING ITS OWN RESEARCH AND DEVELOPMENT PROGRAMS. WHILE THE BOARD COULD NOT PRESCRIBE A SOLUTION, IT THOUGHT THAT AN INDUSTRY SUPPORTED INSTITUTE, POSSIBLY SIMILAR IN SOME RESPECTS TO THE ELECTRIC POWER RESEARCH INSTITUTE, OR THE GAS RESEARCH INSTITUTE, MIGHT PROVIDE A VEHICLE FOR SUPPORT OF PRODUCT-ORIENTED DEVELOPMENT PROGRAMS.

BEFORE I COMPLETE MY FORMAL TESTIMONY I WANT TO POINT OUT THAT THE BOARD WAS NOT ASKED, NOR DID IT ATTEMPT, TO RECOMMEND SPECIFIC BUDGET OR FUNDING LEVELS FOR THE DEPARTMENT'S SOLAR PROGRAM IN GENERAL OR FOR ANY OF ITS COMPONENTS. HOWEVER, THE PANEL ASSUMED A CONTINUED, LIMITED AVAILABILITY OF FINANCIAL RESOURCES FOR THE PROGRAM AT APPROXIMATELY THE 1982 APPROPRIATED BUDGET LEVEL.

MR. CHAIRMAN, I WOULD BE HAPPY TO ANSWER ANY QUESTIONS YOU OR MEMBERS OF THE COMMITTEE MAY HAVE.

* * *

VICTORIA J. TSCHINKEL

February, 1981 - Present	Secretary, Florida Department of Environmental Regulation
September, 1977 - February, 1981	Assistant Secretary, Florida Department of Environmental Regulation
August, 1976 - September, 1977	Assistant to the Secretary, Florida Department of Environmental Regulation
May, 1976 - August, 1976	Environmental Specialist III, Florida Department of Environmental Regulation
October, 1974 - May, 1976	Field Inspector, Florida Department of Environmental Regulation and Trustees of the Internal Improvement Trust Fund
September, 1970 - September, 1974	Biologist and Librarian, Tall Timbers Research Station

A.B.(Zoology), University of Calfornia, Berkeley

Memberships in several environmental organizations

Mr. **Fuqua**. Thank you very much, Vicki.

Mr. Thompson.

STATEMENT OF GRANT P. THOMPSON, CHAIRMAN, CONSERVATION PANEL OF THE ENERGY RESEARCH ADVISORY BOARD

Mr. **Thompson**. Thank you, Mr. Chairman.

My name is Grant Thompson. I am a senior associate at The Conservation Foundation, but I am testifying today not on behalf of The Conservation Foundation, but as a member of ERAB, and as chairman of their Conservation Panel.

With the committee's permission, I would like to have inserted in the hearing record, my prepared testimony, as well as a copy of the report of our Panel entitled "Energy Conservation in the Federal Government: Research, Development and Management."

Mr. **Fuqua**. We will insert the statement as part of the record. We'll make the report part of the overall committee files.

Mr. **Thompson**. Splendid.

I'd like to begin by thanking the members of the Conservation Panel, who were drawn not only from ERAB, but from the universities, local government, industry, and nonprofit groups. Taken collectively, they represented the best minds on conservation and decades of practical experience on conservation as it is applied in the real world.

It is no secret that conservation is made up of thousands and thousands of investments and decisions—large and small, thus it would be impossible to summarize the Board's report adequately within the time available. That duty belongs not with the advisory board, not with the congressional committee, but with skilled dedicated administrators in the executive branch working from adequate analytic base and devoting sufficient resources to the task. Instead of that, I would like to highlight three themes of the report that come out. The first theme is that the market plays a necessary, but not always sufficient role in inducing economically justified energy conservation R&D. That is, there is a vital role for Government and Government policy.

The second theme is that the problem facing the Department of Energy ought not to be how to find energy conservations projects that are worthy of support. But, rather how to sort out and make priorities among those large number that demonstrably conform to administration criteria.

Third, that management and adequate deployment of money and personnel resources are recurring problems for energy conservation within the Federal Government; both in the R&D programs themselves and in conservation undertaken by the Government in its own behalf.

Let me elaborate on these three themes briefly.

First the question of markets. The Board acknowledges that markets are absolutely necessary to induce energy conservation. There is nothing like price to attract the attention of people who are interested in their total budget and the part that energy—the purchases of energy—represent in that. In its examination the Board found that there are limits to markets. Let me talk about four of those limits. First, in important areas of energy supplies energy prices are controlled, both for electricity—the production of which consumes a third of the basic resources of this country—and for natural gas price controls exist. Thus, the market is simply not free and not inducing sufficient conservation and conservation R&D in those areas.

Second, markets don't reach important segments of energy use. Commercial building tenants, for example, who come into a building after it is built, have no control on the insulation; on the design; or on much of the operation of the energy components of that building, even though their rents pay for it.

Third, markets don't support long-range R&D. They certainly don't support nonproduct R&D that is nonpatentable. Thus, important parts of conservation research and development are systems or know-how of putting together existing products in innovative ways where no patent or trade-secret rights can be capitalized upon by an entrepreneur.

Fourth, markets don't take into account enormous national security and environmental benefits of energy conservation.

The effect of this is there is still substantial room for Government policy. We have heard a good deal of discussion that markets alone will induce sufficient conservation and that markets should be the single role—the single policy instrument.

If I could make an analogy, we can think of the violin as an important—indeed a premier—instrument in an orchestra. Yet, no conductor would think it sensible to play Beethoven's 9th Symphony using only a violin. In the same way, it is not sensible to make our energy policy on only one string. It needs to be more than a one-note energy policy.

The second point grows out of the first, that is if we assume that market alone does not cover the area. Then the question is, in a time of limits, what should the Government support? It is well known that the Government—that the Department of Energy has adopted a four-part test for its R&D. That is to be high risk, high payoff, long run, and generic. In the Panel and Boards examination of energy conservation research and development—both programs that had been supported in the past and programs which might be supported but had not yet enjoyed support—we accepted for the purposes of our examination this four-part criteria. We found there were not too few worthy projects but in fact too many worthy projects, even for a very large level of support.

The Department, in the Board's opinion, needs to look at the very many choices that face them for attractive Government investments; put them into a priority order, perhaps using our report as a starting place in making those priorities, and then fund them and carry them out vigorously.

This leads me to the third general theme of this report, which is the question of management of resources and money. In our report we deal on two sides of this issue. Both on the research and development side of management and resources and also on how Government itself manages its own energy use. This morning I'll speak only about the management and the resources available for R&D.

We note three areas of concern as research managers within the Department of Energy. First, we note the very large number of personnel changes and the absolute losses in the conversation branch at the Department of Energy.

Second, we notice that there has been an absolute program loss in dollar support over the last several years. In bringing up this point the Board simply repeated a position that it had taken in its earlier priorities report that there is an imbalance in funding, within the Department, and that the R&D on the demand side—the conservation side—needed a larger amount of resources.

Finally, and I think importantly in research and development operations, there are enormous planning uncertainties, which make continuous good science impossible. In 1981, for example, there were 22 rescission requests totaling $306 million in the conservation budget alone. As anyone who has tried to sustain a program under that kind of uncertainty and continual start-stop, plan no don't plan, can attest, it is extremely difficult to get high quality work of the kind the Nation deserves in this sort of an atmosphere.

Mr. Chairman, these are just three themes out of our report which is, we hope, sufficiently detailed to be of assistance to the Department and to Congress as it deliberates the budget questions. Yet it is not so detailed as to be the kind of program planning which needs to be done by skilled committed managers, and I'd be delighted to answer questions on this—on any specific question.

Thank you.

[The prepared statement of Mr. Thompson follows:]

TESTIMONY
before the
HOUSE SCIENCE AND TECHNOLOGY COMMITTEE
concerning the
REPORT OF THE ENERGY RESEARCH ADVISORY BOARD
on
ENERGY CONSERVATION AND THE FEDERAL GOVERNMENT
by
GRANT P. THOMPSON
March 9, 1983

Good morning. My name is Grant P. Thompson. I am a Senior Associate at The Conservation Foundation, a Washington, D.C. based non-profit research organization. But this morning I am testifying, not on behalf of the Foundation, but rather as a member of the Energy Research Advisory Board (ERAB) of the United States Department of Energy. Specifically, I am testifying as Chairman of that Board's Conservation Panel.

In late fall, 1982, the Conservation Panel completed its work on a report undertaken in response to a request from the Deputy Secretary of Energy that ERAB look at what research and development activities would be appropriate for the Federal government to support in view of the redefinition of the appropriate Federal role developed by this Administration. With some modifications, that report was unanimously adopted by ERAB as an official Report to the United States Department of Energy and forwarded to the Deputy Secretary on January 12, 1983. With the permission of the Committee, I would like to include the entire text of that report, entitled "Energy Conservation and The Federal Government: Research, Development and Management," into today's hearing record.

Before I begin discussing the contents of the Report, I would like to pay tribute to the dedicated work of the members of ERAB's

Conservation Panel. As this Committee knows, ERAB panels are composed of both ERAB members and experts selected for their distinguished records of knowledge and judgment in the field under study. The Conservation Panel was especially favored in this regard with the services of men and women of national and international reputations in energy conservation, both research and development and practical applications in the business world. Panel members, drawn from industry, the universities, local government, and the non-profit world, worked for over a year to examine the work of the Department, to learn what private industry was doing, and to make judgments about a vast array of programs and opportunities. In addition, the Panel received excellent briefings from relevant government departments, from private industry, and from technical experts on conservation. Unlike many committee reports that are drafted by staff and simply modified or approved by the expert panel, this conservation report represents the dedication and hard work of Panel members themselves, supported, I might add, by skilled staff work supplied by the Department of Energy.

I make these points about the Panel and its work not only because its members deserve the credit their work earned them, but also to underline to the Committee that the Report in front of you represents informed, independent judgments of a body of outside experts that included some of the best thinkers and practitioners this country has available.

Now, let me turn to the substance of the Report itself.

In a complex report, covering conservation R&D opportunities in virtually all sectors of the American economy, it is obviously impossible to summarize the report in any adequate way. Conservation is simply too detailed and diverse to permit a few simple summarizing remarks to convey the breadth of opportunities the Board discovered. Therefore, let me organize my remarks into four sections. First, I would like to discuss the structure of the Report itself. Second, I would like to discuss the Board's findings on how the Departmental criteria should be applied to energy conservation research and development. Third, I would like to describe a few of the R&D opportunities in each of the end-use sectors. Finally, I would like to discuss the Board's views on R&D that the Department should conduct on behalf of the Federal Government as a large consumer of energy and how its own energy consumption could be better managed.

Structure of the Report

The Report is divided into three major sections. In the first section ("Introduction") the Board defines energy conservation, noting particularly those characteristics that make it different from energy supply. The Report notes that conservation typically comes in small packages, so that R&D on the topic will not be composed of a few large projects, but rather a very large number of smaller programs, each with potential individual payoffs that are not large, although cumulatively quite important. The Report also notes the importance of non-technical R&D for energy conservation, since many of the most important questions in the field concern how people will actually use energy in practice and how they will react to various kinds of information (including price information).

The Introduction also includes a discussion of how the Government's criteria for Federal R&D (that it be long-term, high-risk, potentially high payoff and generic in character) apply to energy conservation R&D. The Panel and the Board did not examine in this report whether those criteria are appropriate or workable, but instead simply accepted them as a given. The Board concluded that in applying these criteria to energy conservation R&D, it is important that the Department look realistically at the market in which a particular research development must fit in order to judge whether or not the relevant industry is able to support R&D or can market it when developed.

The Introduction also contains a discussion of the limits of markets as instruments of policy. Although the Board accepts the premier role that markets must play in energy policy, this section of the Report describes a number of instances in which markets may fail to apply correct pressure on decision-makers or may fail to provide sufficient incentives to reward private decision-makers for actions that are clearly in the economic and security interests of the country as a whole.

The Introduction serves as an intellectual framework for the work that follows, setting out how the Board believes the Federal government should think about energy conservation R&D if that source is to play the important role that it should in this country's energy future.

Use of Departmental Criteria for R&D Funding

The Department has adopted four criteria for support of energy R&D. Each of them needs to be examined as it affects energy conservation R&D.

High Payoffs. In the case of some energy conservation R&D, the important point is that although conservation payoffs may not be high individually, when they are accumulated over the entire economy, the payoffs can be quite high. Therefore, in assessing particular candidate technologies for support, the proper test is the effect at realistic levels of deployment, not simply the benefits from the first few applications.

In addition, high payoffs depend on the ability of the entrepreneur who takes the risk to capture the benefits of innovation. In the case of at least some energy conservation R&D, the payoffs are a result of a better understanding, practice, or a combination or design tht cannot be protected by a patent. In these cases, the question of payoff must be examined carefully to ascertain whether there is any likelihood that the risktaker will profit. If there is no opportunity for profit, Government support may be warranted.

Importantly, in the case of conservation, at least some of the payoffs are in the form of external benefits to society that are not usually taken into account in making R&D decisions. Environmental and health benefits from fuel not consumed are conventional examples. The national security implications of energy not imported is another clear benefit.

High Risks. Risks come in several varieties. There is pure technical risk ("Will the device work?"). There is economic risk ("Will consumers buy this innovation at the price it costs to produce?"). Finally, there is risk associated with the acceptance of new technologies or systems where nontechnical or noneconomic barriers thwart deployment. In this last category, R&D that includes some verification or demonstration may be appropriate for the Federal Government to fund.

Long-term. Long-term has somewhat different meanings according to the industrial segment to which it is applied. In making judgments of what constitutes long-term, the Federal Government needs to be sensitive to the structure and incentives of the market in which the R&D will operate. Evidence suggests that even energy conservation investments that are simple applications of known technologies must show a higher rate of return than more conventional production investments if they are to be funded privately; this may be a relevant consideration in funding decisions.

Generic. Much of the basic work in conservation is highly generic, providing knowledge that can be used in applications in all sectors. In the same fashion, much of the nonhardware research that the Board endorses in the Report is generic.

Federally Supported Conservation R&D

In these sections of the Report (Section III, "Federal Energy Conservation Research and Development") the Board examines three topics: sector-by-sector R&D appropriate for Federal support; research management at DOE; and the role of state and local governments.

By way of introduction, the Report notes that in the discussions of R&D appropriate for each sector, specific suggestions are intended to be illustrative rather than exhaustive of R&D that deserves support. In other words, the Board believes that there is a very large menu of potential projects that meet the present Federal criteria and, by identifying a few areas, we do not mean to exclude others that would also meet these R&D criteria.

On the subject of budgets, the Report notes,

> Overall funding levels proposed in the President's budget are too low. As stated in its Federal Energy R&D Priorities report, the Board recommends that a budget at the 1982 level is more nearly appropriate.

Each sectorial discussion is divided into four sections (character of the sector, how much R&D is the private sector supporting?, what R&D has the Federal Government funded?, and what R&D should the Government fund?). It is worth noting that the Board found reliable data on the extent of private energy conservation R&D funding extremely difficult to obtain or evaluate. Using the sources available to it, the Board concluded that conservation R&D in the private sector has probably been less than $1 billion per year and most probably only half or less than that. Most energy-intensive industries appear to be doing less today than they were a year ago and will do far less for next year because of the highly adverse impact that the economy is having on industrial budgets. In addition, private R&D is apparently concentrated in only a few industries, so that many industries that would benefit from conservation R&D are conducting little or none of it.

Industrial Sector. The Board recommends that R&D funded by the Federal Government be conducted along three lines: first, there needs to be work on reducing energy waste both by improving initial combustion efficiencies and recovering heat still being rejected to the atmosphere; second, some advanced cogeneration concepts deserve support; and third, certain generic processes need to be improved to increase efficiencies in a cost-effective manner.

The industrial programs of the Department received support by ERAB in its Federal Energy R&D Priorities report; the Board reaffirmed that high rating in this Report. The sensitivity to the diversity of the industrial sector, the wide use of cost-sharing and cost-recovery techniques, and the attention to the needs of users that could not be met by the private sector working alone were key elements in the Department's industrial energy conservation program and should continue to be a feature of Federal Government support.

Building Sector. The Board noted the diversity and importance of this sector and its high degree of fragmentation. The industry itself is able to support only a very small amount of R&D, particularly when compared with the potentials that exist for cost-effective energy conservation.

The Board believes that the Federal R&D program in this area should include four elements. First, research on the building itself, including components, envelope, and as a system; second, research on products used within buildings; third, research on community-scale energy programs; and fourth, behavioral and institutional research.

The Autombile and Truck Sector. The Board notes that this sector consumes large quantities of petroleum. The Board believes that some work on conservation should continue in transportation, particularly in those areas suited to cooperative research with industry. As to automobile technologies, the Board recomends that engine development concentrate less on particular engine types and more on use of innovative materials and designs. For trucks, the Board favors work in materials, in use of waste heat, and in transmission and braking technologies. Finally, the Board notes that there are areas, including traffic management and information programs that only Government can be expected to fund.

Multi-Sector Research and Development. The Board recommends a program of R&D in this area that includes tribology (the study of design, friction, wear, and lubrication of interacting surfaces in relative motion), combustion technology, heat exchangers, and advanced materials research.

Agricultural Sector. Although not within the purview of the Department of Energy, the Report notes a number of areas that show promise for energy savings on the farm.

Research Management at DOE: Continuity and Stability Needed.

The Board expressed its concern about three areas of R&D management within the United States Department of Energy:

o Personnel changes and losess that affect program quality;

o Absolute program support loss that withdraws funding from vital programs; and

o Planning uncertainties that interrupt the continuity of R&D.

Role of State and Local Government.

The Board noted the excellent work that a number of states have done in energy conservation R&D and demonstration. Suggestions have been made that states will pick up more of the research support role as the Federal Government decreases its activities. The Board believes that, while some increased activity would be possible, particularly in evaluating Federal programs passed through to the states, any expectation of a massive shift in this direction is simply unrealistic. If the research effort on energy conservation is collapsed at the Federal level, states will not make up the difference.

Energy Conservation in the Federal Government

The Board was also asked to consider how the Federal Government itself uses energy, whether R&D could assist the Government in improving its own energy use, and whether energy conservation management was adequate for the opportunities available.

The Board noted the factors that make energy conservation a particularly difficult task for the Federal Government: short planning horizons, mission emphasized over cost, and lack of direct cost pressures on those making capital or operating decisions. The Conservation Panel had the benefit of a number of excellent briefings from large industrial firms that have developed and implemented energy management systems, including systems for encouraging internally-funded R&D on conservation. Experience in private industry suggests that the potentials for careful management and appropriate R&D are enormous.

The Board concluded that a management system for energy conservation for the Federal Government needs the following features to ensure success:

- There must be top management commitment and support.
- Program officers responsible for conservation must be committed to that goal and must transmit that commitment to other employees, including making performance in conservation part of job performance ratings.
- The organization must have the financial ability to invest in conservation; energy savings will be small without expenditure of capital and operating funds, together with management time.

- There must be a data collection and management system and a control system that makes comparisons with prior performance and with goals.
- There must be a system of long-term planning and goal setting.
- Technical resources must be available, either within the organization or from other sources, to provide information, evaluation, and diagnosis methods and instruments.

Specifically applied to the Federal Government, the Board recommends that the Office of Management and Budget should be responsible for energy management, monitoring and data collection; that the Federal Government should adopt life-cycle costing techniques to its purchases; and that line item amounts should be added to the budget of each Federal agency for capital procurement and retrofit-renovation expenses for energy conservation purposes.

Moving from energy management to research and development, the Board concluded that the Federal Government should conduct some energy conservation R&D not for the benefit of the Nation as a whole, but rather in its own private interest as a large user of energy and purchaser of energy-intensive products. (If the Government's R&D for its own benefit has spill-over benefits to the Nation as a whole, so be it.)

The Board noted that procurements can be divided into three categories. First, there are some items for which the enterprise is the sole buyer or maker. For these items, if the Government wants to improve its own energy efficiency, it must conduct R&D itself, since no private market exists to drive improvements. Second, there are goods and services purchased of which the Federal Government is either a significant customer for the product or the product represents an important component of the Government's spending. R&D in energy conservation is justified as an investment that will be returned in tax dollars saved. Finally, there are some goods and services simply purchased in the market, with efficiency improvements left to the vendors to make and offer.

The R&D that the Government should take in the first two categories of purchases is simply the kind of R&D that any purchaser would undertake simply because it is in its own best self-interest to do so.

The Board recommends that R&D on efficiency in military hardware and materiel should be conducted by the Department of Defense. (It would be appropriate to establish a highly visible office for this purpose within the Department of Defense, with a separate budget to ensure that sufficient management attention is paid to the opportunities available.) For other Federal Government R&D on its own behalf, the Department of Energy, working directly or through the National Laboratories, the National Bureau of Standards, the General Services Administration, industry, universities and contractors, would be responsible for energy conservation research.

Conclusion

This testimony summarizes only the highlights of a long, detailed, and complex report. I would be pleased to answer any more specific questions the Committee may have.

Thank you.

Biographical Summary

GRANT P. THOMPSON

Grant P. Thompson, Senior Associate at The Conservation Foundation, is responsible for research programs in international, national, and local energy policy. His research interests include energy pricing; legal, regulatory, and economic strategies for carrying out energy policy; energy conservation; and solar energy. Before joining the Foundation, he was Institute Fellow and Director of Energy Research at the Environmental Law Institute. Prior to that, he was associated with the law firm of Jones, Day, Reavis & Pogue.

Among Mr. Thompson's publications are: Energy Pricing and Public Policy (with Thomas C. Schelling); Building to Save Energy: Legal and Regulatory Approaches; Energy: The Next Twenty Years (with Landsberg, et al.); State of the Environment 1982 (contributor); Legal Barriers to Solar Heating and Cooling of Buildings (with Miller et al.); and Energy and the Social Sciences (with Landsberg, Schanz, and Schurr).

Mr. Thompson has served as a consultant to Brookhaven National Laboratory, to the Pacific Northwest Regional Commission, to the Administrator of the Federal Energy Administration, to NASA, and to the Department of Transportation, among others.

He serves as a member of the Energy Research Advisory Board to the United States Department of Energy, as a member of the Advisory Board of the Electric Power Research Institute, as a member of the board of trustees of Scientists' Institute for Public Information, INFORM, Inc., and The Sidwell Friends School. He is Clerk of Friends Meeting of Washington.

Mr. Thompson received his LL.B. from Yale Law School, his M.A. from Oxford University, and his B.A. from Pomona College. He is married, and his family includes two children.

Mr. **Fuqua**. Thank you very much, Mr. Thompson.

Dr. Trivelpiece, did you care to comment. I guess I got out of order, in that you were going to introduce the Panel and I jumped the gun. I apologize.

Dr. **Trivelpiece**. No, I don't have any prepared statement here this morning, Mr. Chairman. I do have a relatively limited role to accompany the witnesses here and represent the Department, should that be appropriate. I wanted to take the opportunity to express on behalf of the Department our appreciation for the hard work that these ERAB Panel members go into in order to prepare these reports.

As Director of the Office of Energy Research I have some of the administrative responsibilities associated with helping ERAB coordinate its activities, and in that regard I help coordinate some of the Department's responses to the various Panel reports. I would be happy to answer any questions, or if I'm unable, to communicate these back to the Department and seek answers on any policy matters or issues that come up in connection with the questions that you ask of the people here today.

I assure you that we do take these recommendations seriously. They are advisory in character, of course, and we do have to regard them as advice and take them into account as appropriate. We don't necessarily always agree with them, but we always appreciate the efforts that these people go into to provide this to us.

Mr. **Fuqua**. Do you make a formal response to the recommendations of the ERAB Committee or take it under advisement?

Dr. **Trivelpiece**. That varies with the circumstances. It is submitted formally to the Secretary, and in some cases a formal or semiformal review process is undergone, in which case then we do look at the individual recommendations and try to come to some conclusions regardless of the specific actions. In other cases the information is, in a sense, assimilated during the budget process in the way it is taken into account, but there is not always a response to a particular item in the formal sense that your question would imply.

Mr. **Fuqua**. Dr. Bennett, you mentioned a report that the ERAB Committee was doing for the Secretary of Energy. Would it be possible—after he receives a copy—for the committee to have a copy of that?

Dr. **Bennett**. Yes, sir.

[The report mentioned above follows:]

THE FEDERAL ROLE IN ENERGY R&D

TABLE OF CONTENTS

Page

CHAPTER I - INTRODUCTION 1

A. BACKGROUND 1

B. METHODOLOGY 2

C. CONCLUSIONS & RECOMMENDATIONS 6

CHAPTER II - ELECTRIC RELATED SUPPLY 9

A. BACKGROUND AND INTRODUCTION 9

B. CURRENT R&D FUNDING 10

C. APPLICATION OF FEDERAL ROLE CRITERIA 13

1. Magnetohydrodynamics (MHD) 14

2. Geothermal 15

3. Hydropower 15

4. Electrical Energy Systems and Energy Storage Systems 15

5. Solar Power Technology 16

6. Magnetic Fusion 17

7. Uranium Resource Assessment 17

8. Uranium Enrichment 17

9.a. Conventional Reactor Systems (Other than Safety) 18

9.b. Conventional Reactor Systems (Safety) 18

10. Breeder Reactors and Other Advanced Reactors 18

11. Nuclear Waste 19

12. Mining R&D 19

D. SUMMARY AND CONCLUSIONS 19

TABLE OF CONTENTS
(Continued)

Page

CHAPTER III - LIQUIDS AND GAS SUPPLY 22

- A. BACKGROUND AND INTRODUCTION 22
- B. GENERAL CONSIDERATIONS 23
- C. CURRENT R&D FUNDING 26
- D. APPLICATION OF FEDERAL ROLE CRITERIA 26
  - 1. Advanced Technology 27
  - 2. Coal Liquefaction/Surface Coal Gasification 27
  - 3. In Situ Coal Gasification 28
  - 4. Enhanced Oil/Gas Recovery 32
  - 5. In Situ Oil Shale 32
  - 6. Biomass Energy 33
  - 7. Alcohol Fuels 33
- E. SUMMARY AND CONCLUSIONS 34

CHAPTER IV - CONSERVATION AND IMPROVED END-USE UTILIZATION 36

- A. BACKGROUND 36
- B. APPLICATION OF FEDERAL ROLE CRITERIA 36
  - 1. Coal Combustion Systems 36
  - 2. Heat Engines and Heat Recovery 39
  - 3. Fuel Cells 39
  - 4. Buildings and Community Systems 40
  - 5. Industrial Conservation 42
  - 6. Transportation Conservation 43
  - 7. Multi-Sector Conservation 44
  - 8. Solar Applications for Buildings 45

TABLE OF CONTENTS
(Continued)

Page

9. Solar Applications for Industry 46

C. SUMMARY AND CONCLUSIONS 47

CHAPTER V - TECHNOLOGY BASE 49

A. DISCUSSION 49

APPENDIX A - Charge Letter

APPENDIX B - Energy RD&D Program Budget Summary

APPENDIX C - 1982-1986 Electric Power Research Institute R&D Budget

APPENDIX D - 1982-1986 Gas Research Institute R&D Budget

LIST OF TABLES

		Page
FIGURE 1	EPRI FUND ALLOCATION BY TIME PERIOD	12
TABLE 1	ELECTRIC RELATED SUPPLY THE APPROPRIATE FEDERAL ROLE BASED ON CHOSEN CRITERIA	21
TABLE 2	PRIVATE SECTOR R&D	29
TABLE 3	LIQUID AND GAS RELATED SUPPLY THE APPROPRIATE FEDERAL ROLE BASED ON CHOSEN CRITERIA	35
TABLE 4	CONSERVATION AND IMPROVED END-USE UTILIZATION R&D BUDGET SUMMARY	37
TABLE 5	CONSERVATION AND IMPROVED END-USE TECHNOLOGY THE APPROPRIATE FEDERAL ROLE BASED ON SELECTED SUBCRITERIA	48

THE FEDERAL ROLE IN ENERGY R&D

PANEL MEMBERS

William McCormick, Jr.
President
American Natural Resources Co.
1 Woodward Avenue
Detroit, MI 48226

Dayton Clewell
Vice President (Retired)
Mobil Oil Corporation
34 Driftwood Lane
Darien, CT 06820

Floyd L. Culler, Jr.
President
Electric Power Research Institute
PO Box 10412
Palo Alto, CA 94303

Henry R. Linden
President
Gas Research Institute
8600 West Bryn Marr
Chicago, IL 60631

Eric H. Reichl
President (Retired)
Conoco Coal Development Company
PO Box 786
Greenwich, CT 06830

Roland W. Schmitt
Senior Vice President
Corporate Research & Development
General Electric Company
Building K-1, PO Box 8
Schenectady, NY 12301

Grant Thompson
Senior Associate
The Conservation Foundation
1717 Massachusetts Avenue, NW
Washington, DC 20036

Victoria J. Tschinkel
Secretary
Department of Environmental
Regulation
State of Florida
Tallahassee, FL 32301

CHAPTER I

INTRODUCTION

A. BACKGROUND

In August, 1981, the Deputy Secretary of Energy sought the advice of the Energy Research Advisory Board (ERAB) concerning DOE's R&D priorities and on the "hard choices" the Department must make in determining which programs to pursue and which to de-emphasize, considering the more limited budgetary resources available to DOE. In November, 1981, ERAB completed its report on "Federal Energy R&D Priorities," which included specific recommendations on which energy research and development programs should be given priority and which should not.

In assessing program priorities in its 1981 report, ERAB employed seven specific criteria, including whether or not a Federal role in a given R&D program area was appropriate. Other criteria that were used in the 1981 report to establish program priorities included: technological potential; urgency of R&D; economic potential; benefits vs. R&D costs; contribution to energy/national security; and health and safety impacts. Thus, while the appropriateness of the Federal role is a necessary condition for justifying Federal energy R&D support, it is not sufficient.

Because the Federal role criterion is so central to every DOE funding matter addressed by ERAB and because ERAB was not satisfied with its evaluation of the Federal role criterion in its 1981 report, the Chairman of ERAB requested (see Appendix A) that a Working Group of ERAB members and panelists examine in more detail the appropriateness of the Federal role in each major Federal energy R&D program area. Thus, the present report focuses only on the one criterion of the appropriateness of the Federal role and evaluates each of DOE's major energy R&D programs (see Appendix B, taken from the 1981 ERAB report on Priorities) against this criterion. Because the present report only considers this one criterion, it contains no specific funding recommendations and should not be interpreted as establishing energy R&D funding priorities. The assessments of appropriate Federal role in this report have been compared to those in the earlier Federal Energy R&D Priorities report, and they are consistent.

B. METHODOLOGY

In order to evaluate the appropriate Federal role criterion in greater depth for each R&D program area, the ERAB Working Group identified several subcriteria by which each program would be judged:

1. The current and expected future scope and amount of private-sector funding relative to requirements for an orderly R&D program. If that funding appears adequate, (or if past private or Federal funding has been adequate to establish feasibility) there would be little need for a Federal role unless there are regulatory, policy, or environmental reasons.
2. Amount of development time to first commercial payoff. In this context, "long-term" implies a time period longer than a particular industry would find acceptable for normal business risks. (It should be noted that "long-term" and "short term" have very different meanings in different industries).

3. Degree of risk of R&D to private-sector development:
    a. Technical risk--that the end-product cannot be developed.
    b. Market risk--that the end-product will not attract customers at a price which would be profitable.
    c. Policy (governmental) risk--that policy, or the possiblity of policy changes, will make investment in R&D unattractive.
4. Need for Federal energy R&D involvement to support regulatory, environmental, or policy responsibilities. Some types of R&D, even though relatively low risk and near-term, may not be either appropriate or attractive for private investment.

The nature of the Federal role will vary with, among other factors, the state of development of the technology. As a general matter, a primary Federal role is seen in basic research and the exploration of new phenomena. As a technology reaches process or product development and then full-scale demonstration, the private sector role should grow relative to that of the Federal government; the exact course of that change should reflect the risk that remains. In this regard, ERAB recommends to DOE that the following guidelines be applied:

o Beyond the basic or exploratory research phase, DOE should insist on a significant level of co-funding by the private sponsor to assure that the technology is truly viewed as worthy of funding. This must be more than just a "token" private contribution. Projects should be judged by the willingness of the sponsor to put private R&D dollars at risk. This is a far more reliable criterion than the often quite inaccurate and unreliable "appraisals" commissioned by DOE or private sponsors to justify projects where many of the resulting economic estimates are suspect.

- To provide further incentive for industry R&D, DOE should allow the resulting information to remain proprietary with due regard to free rights for the government's own use and willingness of the private sponsor(s) to license others at reasonable rates.
- Whenever private co-funding is substantial, guidelines should be established which allow the private sector participant(s) to manage the project without undue involvement from DOE. Unwillingness to do so has resulted in excessive costs and often very poor judgment regarding program selection and objectives.

The remainder of this report evaluates each energy R&D program supported by DOE in Electric-Related Supply (Ch. II), Liquids and Gas-Related Supply (Ch.III), Conservation and Improved End-Use Utilization (Ch. IV) and Technology Base (Ch. V) against the four sub-criteria listed on page 2. An overall assessment of the appropriateness of a Federal role in support of each of the R&D programs is also included as follows:

- Primary--The Federal Government should be the primary source of support because the industry participation is likely to be small, or the R&D is required to meet the Federal Government's regulatory or policy responsibilities.

- Complementary--Some Federal role is appropriate to complement industry efforts or to assure timely development.

- Minimal--Little or no Federal involvement is warranted because industry efforts are likely to be adequate, or enough Federal/private R&D has been carried out to indicate that commercial viability is limited.

The important R&D programs supporting the technology base are not discussed in detail in Chapter V, because it has long been established that the Federal Government must play a primary role in the support of basic research programs that contribute to new understandings and to expansion of the technology base. Most basic research in the United States is in fact sponsored by the Government. The private sector, in most cases, would find it difficult to recover technology base research expenditures, and therefore generally concentrates on applied research and development. Basic research focuses on exploring and understanding the fundamental laws of nature and the properties of matter and living systems. It is inherently long-term in character and high risk as far as the identifiable practical consequences of any particular project are concerned. ERAB expressed its strong support for the Department's efforts in these areas in its report on Federal Energy R&D Priorities. This report confirms that support, and an overall primary Federal role is assigned to the technology base program.

It is noted that the technology base programs do not include any research in economics or the social sciences, the results of which could be of considerable value in determining how and why decisions are made on energy use and conservation. A majority of the Board recommends that the Department initiate such research, which would also be assigned a primary Federal role.

Finally, this report is not the result of any new data collection or analysis. Rather, it is a survey, intended to consolidate existing material and information as an aid for DOE in considering the broad area of appropriate Federal roles.

C. CONCLUSIONS AND RECOMMENDATIONS

Based on evaluations against the sub-criteria defined earlier in this chapter, ERAB has assigned an appropriate Federal role to each of the energy technology programs, as follows:

1. Electric-Related Supply [1]

Federal Role--Primary

- Magnetic Fusion
- Breeder Reactors and other Advanced Reactors
- Geothermal (Advanced Concepts)
- Conventional Reactor Systems (Safety R&D)
- Nuclear Waste
- Uranium Resource Assessment
- Uranium Enrichment [2]

Federal Role--Complementary

- Solar Power Technology (Photovoltaics, Solar Thermal)
- Electrical Energy Systems (transmission, distribution, rotating machinery) and Energy Storage Systems[3]

---

[1] Other technologies, e.g., fuel cells and advanced coal utilization (fluidized bed and integrated gasifier/combined cycle) also relevant to electric-related supply are covered in Chapters III and IV, which deal with liquids and gaseous technologies and conservation and improved utilization.

[2] ERAB's 1982 Report on Advanced Isotope Separation recommended that this enterprise be made an entirely independent self-financing agency (like TVA). However, as long as it is a DOE program, the Federal role is primary. Revenues in this program cover the Federal expenditures.

[3] Under these programs, research on the effects of electromagnetic pulses (EMP) on the electricity distribution and transmission systems would be a primary Federal role.

Federal Role--Minimal

- Geothermal (Conventional)
- Solar Power Technology (Wind, OTEC)
- Magnetohydrodynamics (MHD)
- Hydropower
- Conventional Reactor Systems (other than safety)
- Mining R&D

2. Liquids and Gas Related Supply

Federal Role--Primary

- Advanced Technology (including new gasification and liquefaction concepts)
- Biomass Energy

Federal Role--Complementary

- In situ Coal Gasification
- In situ Oil Shale
- Enchanced Gas Recovery (unconventional)

Federal Role--Minimal

Because of the extensive Federally supported commercial efforts (the Great Plains Project, the Union Oil Shale Project, and other Synthetic Fuels Corporation projects), and extensive private R&D efforts, the following energy R&D technologies do not appear to be appropriate for future DOE Federal support, other than in advanced R&D:

- Alcohol Fuels
- Coal Liquefaction

- Surface Coal Gasification
- Enhanced Oil Recovery

3. Conservation and Improved End-Use Utilization

Federal Role--Primary

- Building and Community Systems

Federal Role--Complementary

- Fuel Cells
- Coal Combustion Systems
- Heat Engines and Heat Recovery
- Industrial Conservation
- Solar Applications for Buildings
- Multi-Sector Conservation

Federal Role--Minimal

- Solar Applications for Industry
- Transportation Conservation

4. Technology Base

- An overall primary role is assigned to the technology base programs.

CHAPTER II

ELECTRIC RELATED SUPPLY

A. BACKGROUND AND INTRODUCTION

Electricity has been and continues to be a vital element in the economic health of the nation. Electricity has the merit that it can use a variety of energy sources--coal, uranium, water, the sun, wind, as well as oil and gas. It, therefore, can play a major part in the nation's move from the use of increasingly expensive and uncertain oil to more plentiful fuels.

Electricity supply in the U.S. is provided by a network of over 3,000 companies and agencies--privately owned, governmental, and cooperatives. Three quarters of the power is provided by privately owned companies which are regulated by state and federal regulatory bodies. In a period of rapidly rising energy costs, as well as generally high inflation, an effect of the regulatory process has been the serious erosion of the financial strength of the utilities. This situation, coupled with the fact that electricity supply systems are very capital intensive, has a profound influence on R&D funding decisions of utilities. These decisions are also influenced by increases in the cost of fuel and transportation paid by the utilities.

The electricity industry is unique in several aspects. Design, licensing, and construction lead times for new base load generating capacity are 10 to 14 years. The introduction of a successful new technology to the point of reasonable market penetration requires 20 to 30 years. Economically sized units of capacity are often very large, so that prototypes of production scale are large, and usually necessary to bring the financial risks to a reasonable level to assure reliability.

R&D related to electricity supply tends to involve long lead times and very large expenditures for individual projects as a technology reaches the pilot plant and demonstration stages. Such research and development has long been supported both by the private sector (utilities and their suppliers) and by government. In general, the private sector has concentrated most of its efforts on relatively near-term technology (initial use within 10 years), much of it related to transmission, distribution, storage, and utilization. However, industry also has applied significant funding to intermediate-term technology (initial use 10-25 years away).

B. CURRENT R&D FUNDING

The Federal government has historically supported both intermediate-term and very long-term development and relevant basic and supporting research. Thus, the two sectors' approaches have been complementary, with the intermediate-term work in which both have been engaged being carefully coordinated, often involving jointly funded projects. Because of the very long lead time and large investment required to bring new electric supply technologies to fruition, financial support by the Federal government has been of particular importance to the Nation's long-range electricity supply.

Appendix B shows the FY 1982 and proposed FY 1983 R&D funding by the Department of Energy. Funding by the private sector is difficult to determine with precision; however, one major source is the budget of the Electric Power Research Institute (EPRI). The level of R&D supported by the electric utility industry has grown markedly since the establishment of EPRI in 1973. But its budget is expected to remain at about the current level of $275 million in real terms for the next several years due to the financial condition of utilities.

EPRI's five year budget plan (1982-86) is shown in Appendix C, with a breakdown corresponding to that used by ERAB for the DOE budget. It will also be noted that substantial EPRI funding is shown under categories B (liquids and gases), C (conservation and improved end use), and D (technology base) as well as A (electric supply related). Lines 14, 15, 22, 24, and 34 are all electricity-supply related insofar as the EPRI program is concerned, though that is not necessarily the case for DOE's budgets in these categories. Figure 1 is an assessment of the EPRI budget on the basis of time-to-use of the technology being developed, showing that over two-thirds of EPRI's work relates to near-term technology, another quarter to the intermediate-term, and less than 5% to the long-term.

EPRI estimates that electric utility R&D funding outside of the EPRI budget approximately equals that of EPRI. Some of this effort directly involves EPRI projects; but for the most part, the remainder of the individual electric utility programs are of a very near-term nature, such as environmental monitoring, develpment of short-term solutions for equipment and operating problems, and responses to individual regulatory requirements.

The supplier segment of the electric industry (e.g., General Electric, Westinghouse, etc.) has also supported technology development, more oriented toward enhancement of product lines rather than toward long-term high-risk technology. However, the current climate is such that funding from this source might be reduced as utilities defer purchases of new equipment. Furthermore, the supplier companies are often large, diversified enterprises with alternative opportunities for R&D investments in other lines of business. An estimate of supplier R&D during 1979 is in the $250-500 million range.1/

1/ A report prepared by Mathtech, Arlington, VA, for the Department of Energy in 1981 estimates $250 million.

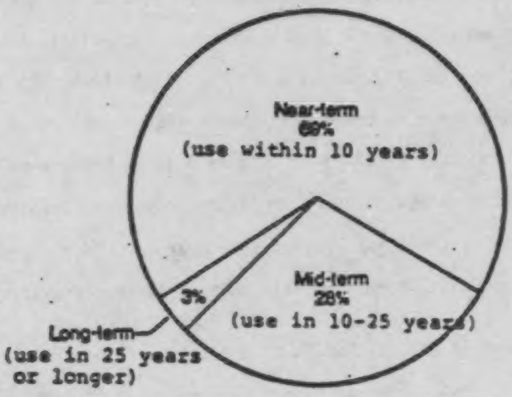


__FIGURE 1__ EPRI FUND ALLOCATION BY TIME PERIOD

In program terms, the complementary nature of the Federal and EPRI R&D efforts is evident by a comparison of Appendices B and C. EPRI's R&D on electricity supply technology is largely related to coal- and uranium-using systems, transmission systems and to distribution components expected to reach commercial use in the near and intermediate terms. Only modest R&D efforts are supported in non-conventional systems, such as advanced geothermal, solar, and wind. For very long-term technology, such as fusion and MHD, there are only minimal efforts in the EPRI program, and the same situation prevails for basic research.

As the Federal government has reduced its support of intermediate-term technology, the effect has been that nationally there is substantial effort on near-term problems and some on very long-term R&D (breeder, fusion), but less on the all-important intermediate-term which will provide the systems of 1990-2010. Thus, there is a very real chance that the Nation will lack the technology for the next generation of systems needed to improve electricity supply efficiency, reduce costs and to meet future requirements for environmental and health protection.

C. APPLICATION OF FEDERAL ROLE CRITERIA[1]

Table 1, at the end of this Chapter, is an assessment of each of the electricity supply technologies from the electric utility perspective using the four subcriteria adopted by the Working Group. While the "Time to First Payoff" shows an immediate category of 10 to 25 years in addition to a long-term category of greater than 25 years, it needs to be emphasized that 10-25 years is a long time from the standpoint of most business decisions, but a relatively short time in electricity related R&D. As a result, a number of these activities in the past have had shared funding by the private sector and the government, heavy Federal involvement in large-scale demonstrations being of particular importance.

---

[1] In applying the Federal role criteria, it is important to recognize that Federal support can take various forms. Obviously, direct funding of R&D activities (in whole or by co-funding with non-Federal sources) is one such form. Other direct forms include loan guarantees and price supports, both of which can involve tax incentives. In this analysis, a Federal role implies some form of direct support, even though there may be general tax benefits that apply.

Table 1 also shows that private sector R&D funding in many of these technology areas is low compared to the funding required to proceed effectively with the developments. In many, the financial risks are very large. The outcome, even with success, is uncertain with respect to the regulatory actions, and the time before real income can be realized is very long.

The growing sensitivity to environmental protection and the need for balancing environmental considerations with the effectiveness of our economy calls for a Federal role in the fields of environmental and health effects R&D. With good basic information, the private sector should be in a position to reduce to practice such environmental control systems as may be practical.

Using the stated policy, together with ERAB's amplifying criteria, based on the judgments in Table 1, the appropriate Federal roles for the electric-related supply R&D areas are as follows:

1. Magnetohydrodynamics (MHD)

   MHD is a high risk technology that has received over $500 million of past Federal R&D support and it is uncertain that the goals can be successfully achieved. This is coupled with uncertainty as to the magnitude of the benefits compared to those of other technologies, e.g., fluidized bed, combined cycle. While a Federal role in the operation of existing facilities can serve to determine the next steps in this program, the Federal role is minimal.

2. Geothermal

Some geothermal resources are presently being utilized by the private sector, i.e., dry steam. For these systems the Federal role is minimal. However, other resources, which are more plentiful, require new technologies with varying degrees of risk. The hot water systems involve moderate risk, while development of means to exploit the hot-dry rock resource is a very uncertain, high risk activity. A primary Federal role is appropriate in pilot plant-sized high salinity hot water systems and in determining the feasibility of hot-dry rock systems, including pilot scale.

3. Hydropower

The technology is at the state where applications are occurring and the risks associated with the development of improvements are within a normal business range. The Federal role is minimal.

4. Electrical Energy Systems (Transmission, Distribution, Rotating Machinery) and Energy Storage Systems

There is high risk as well as little incentive for the private sector to perform the exploratory work on advanced generation and transmission systems and storage concepts. The private sector is capable, financially and from an acceptable risk standpoint, of reducing such systems to practice if the exploratory work leads to favorable results. The Federal role is complementary. In transmission and distribution there is a vital national purpose, as well as assuring reliability, in determining and, as necessary, mitigating the possible effects of electromagnetic pulses (EMP). The private sector is unlikely to undertake such work. The Federal role in this area is primary.

5. Solar Power Technology

The appropriate role of the Federal government in this field has been defined in detail in a separate ERAB report. In summary: With respect to photovoltaic energy, the private sector is engaged in very substantial efforts on photovoltaic materials and modules, aimed at providing high efficiency, low cost P.V. modules. However, a Federal role was found to be important to complement the private efforts, spanning basic research on solar radiation and on improved photovoltaic materials, module development and testing and, when warranted, testing of entire systems of sufficient size to demonstrate the performance and economics of this type of system.

Solar thermal systems have reached the stage that a more limited Federal R&D role is appropriate. Apart from completing the testing of plants now in existence, an appropriate Federal role would include exploration of novel concepts and supporting R&D. The Federal role here is complementary.

Because the potential payoff is quite limited, as well as uncertain, there is little justification for other than a minimal Federal role in ocean thermal electric conversion (OTEC).

The wind industry has both the incentive and the ability to carry out R&D needed for improved wind machines. The Federal role is minimal, but is necessary in completing and testing existing machines and in providing the technological basis for scaling up to the 5-7 MW size.

6. Magnetic Fusion

The payoff of this technology is very long-term and highly uncertain, but the potential is very large. The funding required to bring this concept to fruition is of very large magnitude and it entails high risk. It is clear that private funding is and will continue to be minimal until a magnetic fusion system has been shown to be scientifically and technically feasible. The appropriate Federal role in this technology is primary, including supporting research, the building and testing of test facilities and reactors, and, when timely, large scale demonstrations.

7. Uranium Resource Assessment*

Reasonable knowledge of the total resources of uranium is important to both Federal and private policy-making on nuclear power. DOE's core program is one of analyzing data provided by private industry, which is analagous to similar Federal programs for other natural resources. The Federal role is primary.

8. Uranium Enrichment*

So long as the Federal government controls and operates enrichment facilities, R&D related to enrichment in the private sector is expected to be low. The Federal role is therefore primary. [The May, 1982 ERAB Report on Advanced Isotope Separation recommended that this enterprise be made an entirely independent self-financing quasi-private agency (like TVA), so that R&D and capital costs could be independent of unrelated Federal budget constraints.]

---

*The Federal role is defined by policy.

9.a. Conventional Reactors Systems (other than safety)

There are adequate incentives in the private sector to develop techniques for improved performance of conventional reactor systems. The Federal role is minimal.

9.b. Conventional Reactor Systems (Safety)

While the private sector is spending large amounts for fission reactor safety, there is a need for Federal R&D which serves a regulatory or health and safety purpose rather than a private purpose. Major research on the consequences of hypothetical accidents and on environmental phenomena are examples of such work. The Federal role is primary.

10. Breeder Reactors (and Other Advanced Reactors)

Technical feasibility of the breeder is clear, but development and proof of reliable hardware has not proceeded, the financial requirements to carry out development are large, the time to develop is long and there are major uncertainties as to the time of payoff (as well as uncertainties created by government policy and regulation). To bring this technology to the point at which the level of risk is acceptable to the private sector will at some point require large scale plant design, construction and testing, as well as certainty of government policy. The Federal role is primary.

For other advanced reactors, the time to develop is also long and there are many uncertainties as to payoff. As a result, private funding is very limited. To bring this technology to the point of commericial reliability and use would also require large scale plant design, construction and testing. The Federal role is primary.

11. Nuclear Waste*

The long-term management of nuclear waste is generally viewed as a necessary government function, even though the costs should be borne by the utility sector. Thus, the government has a primary role in any related R&D.

12. Mining R&D

The technological efforts needed to improve coal mining methods are within the range of normal business activity and there is adequate incentive in the private sector to carry them out. The Federal role is minimal.

D. SUMMARY AND CONCLUSIONS

In applying the Federal policy criteria to the electricity sector it is essential to recognize certain structural differences between the electric industry and other industries that affect the business risk/time to payoff decisions by the private sector. The privately owned segment of this industry is a regulated industry so that the normal workings of the market system are constrained. Regulators often are unwilling to authorize risky ventures. Futhermore, the benefits of successful risk taking are unlikely to accrue to the utility, while the penalties of unsuccessful risk taking often have been borne by its stockholders. Also, funds that an unregulated industry might devote to R&D may not be approved by utility commissions reacting to consumer pressures for lower rates in the short term. These conditions mean that the industry and its suppliers are not in a position to fill the funding gap created by the reductions in Federal R&D support in intermediate term technologies.

---

*The Federal role is defined by policy.

As a result of these considerations, unacceptable business risks are reached at a lower level in the electric utility industry than in the unregulated sectors of the energy business. This problem reaches its most critical proportions when it becomes necessary to build large-scale, high cost demonstrations, which are essential elements in proving out the economics and technical aspects of some of the new technologies. And, it must be emphasized, it is often necessary to gain experience with several such large-scale projects before the risks in the use of a new technology are reduced to the level of acceptable business risk, particularly considering the importance of reliability of service demanded from this industry.

The effects of these circumstances on the Federal role are summarized in the final column of Table 1.

TABLE 1

ELECTRIC RELATED SUPPLY
THE APPROPRIATE FEDERAL ROLE BASED ON CHOSEN SUBCRITERIA

PROGRAM	SUBCRITERIA						Criterion:
	Private Funding Relative to Requirement	Time of First Payoff	Degree of Risk			Federal Role: Regulatory, Environmental, or Policy Needs	"Appropriate Federal Role"[c]
			Technical	Market	Policy		
ELECTRIC-RELATED SUPPLY*							
1. Magnetohydrodynamics (MHD)	Low	Long	High	High	Low	Low	Minimal[d]
2. Geothermal[a]	Moderate	Intermed./Long	High	Moderate/High	Moderate	Low	Dominant
3. Hydropower	Moderate	Near	Low	Low	Low	Low	Minimal
4. Electric Energy Systems and Energy Storage Systems[a]	Low	Intermediate	Moderate	High	Low/Moderate	Low	Complementary
5. Solar Power Technology							
a. Photovoltaics	Low	Long	High	High	Low	Low	Complementary
b. Solar Thermal	Moderate	Intermediate	Moderate	High	Low	Low	Complementary
c. Wind	Moderate	Near/Intermed.	High	Moderate	Low	Low	Minimal
6. Magnetic Fusion	Low	Long	High	High	Moderate	Moderate	Dominant
7. Uranium Resource Assessment	Low	No Payoff	N/A	N/A	N/A	High	Dominant
8. Uranium Enrichment	Low	None[b]	High	High	High	High	Dominant
9. Conventional Reactor Systems							
a. Other than Major Safety Studies	High	Near/Intermed.	Low	Low	High	Low	Minimal
b. Major Safety Studies	Moderate	Near/Intermed.	N/A	Low	High	High	Dominant
10. Breeder Reactors	Low	Long	High	High	High	Moderate	Dominant
11. Nuclear Waste	N/A	Gov. Function	N/A	N/A	N/A	High	Dominant
12. Mining R&D	Low	Intermediate	Moderate	Moderate	Low	Low	Minimal

a/ The ratings in this Table apply to the advanced technologies in these programs.
b/ Given current policies.
c/ Rankings do not indicate priorities.
d/ See page 14. Ranking results from high Federal support in the past.

* Other technologies which are also relevant to electric-related supply are covered in other chapters of the report, e.g., fuel cells and advanced coal utilization (fluidized bed and integrated gasifier-combined cycle).

CHAPTER III

LIQUIDS AND GAS SUPPLY

A. BACKGROUND AND INTRODUCTION

Appendix B lists the Federal R&D programs which are the subject of this chapter and gives the FY 1982 Congressional Appropriation and the Administration's 1983 Request to Congress.

Whenever such a review of the entire energy R&D program is undertaken, the issue of proper categorization poses some problems of overlap. For example, coal gasification can be viewed as a key step in conversion to electricity, as well as to liquid and gaseous fuels. Similarly, coal combustion cannot be considered unrelated to liquids and gas utilization. In its importance to the total U.S. energy flow, it ranks near the top of all technologies, particularly in the near and intermediate term. As a result, environmental programs related to coal combustion are highly important in regard to coal's capacity to displace liquid and gaseous fuels. Nevertheless, this chapter will use the categories (programs) represented in Appendix B.

An important sub-criterion to be used in defining the appropriate Federal role is the R,D&D support available from the private sector. A qualitative assessment of the appropriate Federal role is given in Table 3 (at the end of this chapter) as "Primary", "Complementary", and "Minimal" and the reason is given in the accompanying text. Note that, in the context of this chapter, the Gas Research Institute (GRI) fulfills a similar function as the Electric Power Research Institute (EPRI) does for electricity supply in performing private cooperative R&D for a regulated industry. In the case of the GRI, the R&D is mostly concentrated on relatively near-term gas supply and end use technologies, with greater present focus on gas utilization. The Gas Research Institute R&D funding is shown in Appendix D. The GRI program is aimed at compensating for the lack of strong manufacturer or Federal support for end use technology.

B. GENERAL CONSIDERATIONS

With respect to fossil energy R&D matters, the existence of a very broad-based private industry covering virtually all aspects of fossil energy use is of paramount importance. The competence of this industry, particularly in terms of R&D, is not in doubt. Of special importance, furthermore, is the wide diversity of opinion within this competitive industry about virtually every one of the R&D programs included in this chapter.

This diversity is the very essence of the industry's strength, leaving it to the "market place of research ideas" to find the best answers. Recognition of this fact, together with the difficult government/private sector management relationship, has led to the elimination of large, commercial or near-commercial projects (demonstration plants) from the DOE program.

However, in the course of introducing new technologies, the risky and costly "first-of-a-kind" (pioneer or demonstration) project remains of crucial importance. The vehicle established specifically to deal with this issue for ready to commercialize technology is the Synthetic Fuels Corporation (SFC). The current policy of that organization is clearly stated to assure a diversity of technologies for liquid and gas supply from several U.S. domestic fossil resources and by several alternate technologies. In this regard, it is important for DOE to take note of the SFC program in the future and to ensure that its energy

R&D program will best serve to remove technological and environmental barriers standing in the way of SFC projects.

The current Federal R&D programs involve "synthetic fuels" from coal, heavy oil, shale tar sands, biomass, etc., and "unconventional" sources of natural gas and heavy oil--i.e., sources heretofore considered to be uneconomic. A key point to note when considering a Federal R&D role in liquid and gas supply from domestic resources is the existence of commerically proven technology.

In the area of commercial synthetic fuels technology, a full-size shale oil project (Union Oil) is under construction, together with a full-size plant to produce pipeline gas from coal (Great Plains). The latter, a special case of the so-called indirect conversion of coal, is virtually the same technology which can be used to produce liquids. While this specific project will demonstrate gasification under pressure of coarse, non-caking coal, three additional private-sector projects now under construction involve the commerical-scale gasification of fine-sized caking coal, also under pressure. A number of commercial plants are in operation producing liquid fuels from biomass and tar sands (in Canada). Thus, a commercial synthetic fuels program is already in progress based on private sector risk money, with some of it supported by government guarantees.

Therefore, most synfuel R&D involves improvements to existing systems. This can include use of new gasifiers, clean-up gas conversion systems or, as an alternate source of liquids, use of direct hydrogenation. The latter, specifically, is a key segment of recent DOE coal liquefaction R&D up to and including large 200 ton/day pilot units.

To determine what constitutes an "improvement" requires a high sensitivity to commercial factors, to plant reliability, to economics, and to the relative ease of fitting new operations into complex existing manufacturing systems. This knowledge is not usually found in government reseach establishments. This is particularly true where new process improvements of existing technologies are concerned.

Also, the farther removed from process development and the closer the project involves basic science, fundamental data, and the properties of substances, or new insights to unit operations, the more this can be considered an appropriate Federal R&D role. In a generic sense, this can be extended to cover the behavior of solids per se, since the key U.S. domestic substitutes, coal and shale, are solids. Thus, basic research on solids and on solid/liquid and solid/gas systems and, specifically, improved concepts for their separation, fall into the Federal role.

In the area of "unconventional" liquid and gas technologies there are selected R&D opportunities in the high-risk, long-term, high pay-out category which justify some limited Federal role. For example, a Federal role appears appropriate in basic science related to geochemistry, fluid migration in frontier geologic settings, verification of abiogenic origination theories, properties and occurence of hydrates and advanced geophysical diagnostics. There is also a Federal role in R&D on enhanced unconventional gas recovery.

Finally, the Federal role for basic science R&D on gas and liquid supply is uniquely appropriate whenever the research tools or apparatus required are not generally available to the private sector, either because they are too costly to own or to operate or cannot be justified by a single corporate entity. This area is exemplified by certain unique advanced diagnostic tools, many of them one-of-a-kind, available only at the National Laboratories. The program of these institutions should be guided toward this area of basic science as a prime assignment in the fossil fuel R&D area.

C. CURRENT R&D FUNDING

Some information on the private sector R&D expenditures is available, although a more informative picture can be presented by listing the major R&D projects which have been launched by industry. Some of these are supported by government funds, but there are many which receive no such help. Table 2 is a non-exhaustive compilation of these activities. The scope of the work is shown together with the length of time which might be required to first commercial introduction.

The Table also states the risk perceived by the private sector. Apart from Table 2, it is useful to note that according to one source, the 1981 R&D expenditures incurred by the 15 largest oil companies alone was $2.25 billion, most of it related to gas and liquid supply. No significant change in the level of effort was expected for 1982. Thus, the private sector effort represents a large multiple of government effort in this area.

D. APPLICATION OF FEDERAL ROLE CRITERIA

The several sub-criteria utilized in this report have been applied to the gas and liquid supply programs and the result is summarized in Table 3, at the end of this chapter.

In addition, some specific comments on the various programs are given in the following paragraphs:

1. Advanced Technology

This program extends the technology base for coal through research on new processes, technical breakthroughs and improvements in existing coal conversion and utilization technologies. It includes research on materials, heat exchangers, instrumentation and controls, diagnostic techniques, advanced processes, the nature of coal, combustion processes, and a university coal research activity.

The exact amount of private sector R&D in these areas is not readily ascertained, but it is reasonable to conclude that out of the $2.25 billion spent (in 1981) by the 15 largest oil companies on R&D, a substantial amount was assigned to Advanced Technology in all areas including synthetic fuels. The private sector support is thus rated medium on Table 3.

It is re-emphasized that the DOE program in this particular area should be as close to the frontiers of knowledge as possible; it should be generic and not specific-process oriented and should explore areas of high-risk, long-term, high-potential impact (applied process development is much better handled by the private sector). For this type of work, the appropriate Federal role is primary.

2. Coal Liquefaction, Surface Coal Gasification

These two subjects cover virtually the entire coal based synthetic fuel area. The term "liquefaction" is often applied to mean liquefaction by means of hydrogenation, but it also includes "indirect" liquefaction. Gasification is a major component of all systems of converting coal to gaseous and liquid fuels.

Table 2, listing the private sector effort, indicates a very substantial program in both "direct" and "indirect" conversion, with major emphasis on gasification. A large commercial "indirect" conversion plant is under construction in North Dakota and full-size gasifiers of a different design are nearing completion in Tennessee, Illinois, and California. Other full commercial scale projects, including both "indirect" and "direct" liquefaction, have been proposed to the Synthetic Fuel Corporation and have been judged technically mature. Thus, the private funding is high, time to first commercial use is near and while some technical and major market and policy risks remain, it is apparent that the private sector will continue to pursue this subject with and without SFC support, and therefore the Federal role criterion is minimal. This does not preclude some selected work on these systems.

3. In Situ Coal Gasification

This concept has been pursued for well over 50 years here and abroad and has received substantial DOE support in recent years. However, the results did not lead to any significant private sector effort. A specific application, namely to very steeply pitching seams, is viewed as economically attractive by one company and may find commercial use in the near term.

TABLE 2

M #	Private Sector R&D in Progress Note: Foreign/R&D is Treated As "Private")		Length of Time to First Commercial Introduction	Degree of Risk (To Private Sector)
	Advanced Technology			
	Exploratory R&D		N/A	High
	Coal Liquefaction	(Direct Hydrogenation)		
i.	Continuous lab. scale units in operation:	HRI LUMMUS KERR-MCGEE CHEVRON	New direction in hydro R&D can lead to improved two-stage systems. R,D&D may be ready for commercial application in 1990-1992 timeframe.	Technical risk may be reduced if other hydrogenation plant has been built previously; this is likely to be the case.
	Pilot plants in operation 5-6 T/D Scale	EPRI (Wilsonville) CHEVRON (in const'n)		
	200 T/D Scale	ASHLAND (Catlettsburg) Operation under study		
	Commercial Plant 200T/D and larger	H-Coal (Breckinridge, KY) 8000 T/D applied for SFC (Based on Catlettsburg)	H-Coal Project Operation possible 1988/9 if SFC support is available.	Substantial technical risk. Proposed total cost of project (in current $s) $3 Billion. Depending on SFC support, risk may involve 25 to 100% of plant cost.
ign	Continuous lab. scale Pilot Plants in operation up to 10 T/D scale.	BBF (Essen) SAARBERG GmbH 6 T/D NCB (Cheltenham) MITSUI 2 1/2 T/DD (Japan) KAWASAKI 8 T/D (Japan)		Lowest technical risk among hydrosystems, due to close adherence to old German technology.
		RUHRKOHLE O&G (200 T/D) MITSUI/NKK 250 T/D [illegible]	Ruhrkohle O&G are planning 2000 T/D Demoplant. Operation 1986-8 (depends on support by German	Commercial risks would be covered by German Government.

TABLE 2

M #	Private Sector R&D in Progress (Note: Foreign/R&D is Treated As "Private")		Length of Time to First Commercial Introduction	Degree of Risk (To Private Sector)
15	Surface Coal Gasification			
:	R&D Scale			After 1985/6:
	15 T/D	Westinghouse:H.P. Fluid Bed	1200 T/D Westinghouse, reactor considered for SASOL: possible operation: 1985/86.	Technical risk for most new gasifiers can be minimized by test run with projected coal in existing full scale equipment.
	Commercial Scale:			
	10,000 T/D	Great Plains Proj: H.P. Fixed Bed (LURGI)	Great Plains Operation Scheduled for 1984/85.	
	600 T/D	KilnGas (A-C): 60PSIG Rotating Kiln	Kilngas operation scheduled for 1983.	Commercial risks remain unchanged.
	1,000 T/D	Coolwater (TEXACO):H.P. Entrained Solid/O_2	Coolwater operation scheduled for 1984.	
	800 T/D	Kingsport (TEXACO): dto./O		
	400 T/D	Plaquemines (DOW): H.P. Entrained Solid/ASr	Dow plant in operation for several years.	
ign:	Pilot PlanT Scale		NOTE: LURGI and K-T Gasifiers have been in extensive commercial operation abroad for over 30 years	
	150 T/D	R-100: 1500psi LURGI F/B		
	600 T/D	British Gas Slagger: H.P.F/B	Commercial BGC-Slagger scheduled for operation in 1983	
	150 T/D	RuhrChemie/RuhrKohle (TEXACO) H.P. Entrained Solids and hydro-residue.		
	150 T/D	D-Shell: H.P. Entrained Solid		
	N/A	Kloeckner:Molten Iron bath		
	150 T/D	MITI (Japan): H.P. Fluid Bed		
	Commercial Scale:			
	800 T/D	Rheinbraun: H.P. Fluid Bed	Rheinbraun operation scheduled for 1985	
	(700 T/D	RuhrKohle: H.P. Entrained Solid (TEXACO) Proposed)		

NOTE: Associated with gasification proper is extensive Private Sector R&D concerned with conversion of gas (CO, H_2, CO_2, CH_4 mixtures) to liquid fuels and chemicals.

Example: 12,000 bbl/D MOBIL-M plant (conversion of CO/H_2-CH3OH-gasoline) in New Zealand.

Laboratory scale research in progress by GRI, DuPont, MOBIL, BASF, Scientific Design, and many others

TABLE 2

EM #	Private Sector R&D in Progress (Note: Foreign/R&D is Treated As "Private")	Length of Time to First Commercial Introduction	Degree of Risk (To Private Sector)
16.	In Situ Coal Gasification		
	No privately financed R&D activity in this area is believed in progress nor is any expected. Based on results to date Gulf oil have stated that use of this process to gasify vertical or steeply pitching seams appears to have a good economic attraction. DOE financed work has been in the 100-200 T/D range of capacity. This has included work on both horizontal and steeply pitching seams.	Assuming a commercial application to require upward from 1000 T/D capacity, it may be possible to have a full scale unit in operation within 4-5 years, based on steeply pitching seams. No such project has been announced.	The technical risk for in-sit gasification must be considered to be unavoidably high. This is due to the unique sit specific character of this technology
		Since no comparable results have been achieved with horizontal seams (which represent most U.S. resources), no "time-to-commercialization" can be stated.	Virtually every coal deposit represents a new R&D problem before a full scale system ca be designed.

The wide divergence of geological conditions between different coal seams makes each deposit a special R&D subject, and the concept apparently does not lend itself to a once-and-for-all solution. Given this background it is concluded that the Federal role criterion is complementary, mainly on technical grounds.

4. Enhanced Oil/Gas Recovery

In line with ERAB's earlier report on priorities, it is repeated here that the subject is indeed deserving of aggressive RD&D. However, with the exception of some large "unconventional" natural gas resources, such as geopressured gas, the subject is quite adequately, and very competently, covered by the private sector. Aside from these exceptions, the Federal role here is clearly minimal.

5. In Situ Oil Shale

A full-size commerical shale project is now under construction (by Union Oil Company). Although Exxon recently withdrew from a much larger venture, negotiations toward other shale projects are currently in progress at the Synthetic Fuels Corporation. Thus, it is clear that the oil industry is in fact attacking the shale problem with surface processing approaches. None of these projects use in situ shale oil recovery. The reason is the discouraging results from the many million dollars spent over the last 10 years; consistent high levels of oil recovery do not seem attainable. Furthermore, demonstrations of environmental acceptability are difficult, which results in a high policy risk. The subject has received ample support and alternate solutions are available. The appropriate Federal role is at best complementary and possibly minimal.

6. Biomass Energy

For a more detailed review, the reader should consult the special ERAB report on Biomass dated November 1981. The basic conclusions are repeated here. The exact amount of private sector R&D is not known. However, in this highly diversified industry a small amount of funds has been invested in both biomass resource production and conversion technologies. The private sector funding is assessed to be medium relative to the required needs.

DOE R&D should be focused on basic studies of biomass resource production and conversion technologies. High research priority should be given to forests for biomass resource production, because nearly half of all potential biomass will probably come from this resource. Conversion technology research is of secondary importance and should emphasize liquid and gas fuel conversions.

Because forest biomass resource production enhancement deals with basic research, the Federal research role is rated as primary. The conversion technology research, such as discovering microorganisms that will convert lignocellulosic material to alcohols, also depends upon basic studies and the Federal role in this area is primary.

7. Alcohol Fuels

Again the reader's attention is directed to an earlier special ERAB report, entitled "GASOHOL", dated May 1980. The primary alcohol fuel being produced is ethanol from corn grain. While the investment by the private sector in R&D appears to be relatively small, this is a fairly well established technology, although the process would not be economically competitive in the absence of tax subsidies. Cellulosic biomass is more abundant and could be a cheaper base for ethanol production, but this process requires development. The required Federal role investment is therefore rated as minimal, except for some basic research on conversion processes.

E. Summary and Conclusions

In summary, it is noted once again that an approprjate role for Federal energy R&D is one of removing barriers which prevent the private sector from functioning freely. Such key barriers often cause a lack of confidence in energy projects or systems on the part of the public or the investors. Government R&D can help to improve understanding and to reduce risks, particularly those risks related to environmental impact, safety, siting of plants, and plant reliability.

TABLE 3

LIQUID AND GAS RELATED SUPPLY

THE APPROPRIATE FEDERAL ROLE BASED ON CHOSEN SUBCRITERIA

PROGRAM	SUBCRITERIA						Criterion: a/
	Private Funding Relative to Requirement	Time of First Pay-Off	Degree of Risk			Federal Role: Regulatory, Environmental, or Policy Needs	"Appropriate Federal Role"
			Technical	Market	Policy		
LIQUID &-GAS RELATED SUPPLY							
13. Advanced Technology	Medium	Long	High	High	High	Low	Dominant
14. Coal Liquefaction	High	Intermediate	Medium	High	High	High	Minimal
15 Surface Coal Gasification	High	Near	Low	High	High	High	Minimal
16. In Situ Coal Gasification	Low	Long	High	High	High	High	Complementary
17. Enhanced Oil Recovery	High	Near	Low	Low	Low	Low	Minimal
18. Enhanced Gas Recovery	Medium	Near	Medium	Medium	Low	Low	Complementary c/
19. In Situ Oil Shale	Low	Long	High	High	High	High	Complementary
20. Biomass Energy	Medium	Long	High	Mdeium	High	Medium	Dominant
21. Alcohol Fuels	Medium	Long	Low	Low b/	High	Medium	Minimal

a/ Rankings do not indicate priorities.
b/ Subject to current tax subsidies.
c/ The ranking applies only to "unconventional" natural gas resources. The balance of the program ranks as minimal.

CHAPTER IV

CONSERVATION AND IMPROVED END-USE UTILIZATION

A. BACKGROUND

This chapter covers a number of diverse technologies which were included under the subject heading in the November 1981 ERAB report, "Federal Energy R&D Priorities." Many of the conservation and solar technologies would be used by millions of individuals and organizations, many of whom have little or no understanding of or capability for R&D. The R&D Priorities report refers to "the opportunities that exist for efficiency improvements and the unique Federal role in conservation R&D." A strong federal role in selected technologies was also endorsed by the Reports of the Solar R&D Panel (September 1982) and of the Conservation Panel (January 1983).

Table 4 lists the R&D programs covered, the DOE budgets for those programs and an approximate range of private sector R&D funding. While the DOE, EPRI, and GRI budgets are publicly available, private sponsors do not usually release detailed budget information and even the qualitative estimates listed are highly uncertain.

B. APPLICATION OF FEDERAL ROLE CRITERIA

The application of the Federal role criteria for this R&D area is given in Table 5 at the end of this chapter. These are discussed for each individual program in the following paragraphs.

1. Coal Combustion Systems

The objective of this DOE Fossil Energy program is to develop

TABLE 4

CONSERVATION AND IMPROVED END-USE UTILIZATION R&D BUDGET SUMMARY

($ Millions)

		DOE		EPRI & GRI		
		Appropriation FY 1982	Request to Congress FY 1983	FY 1982	FY 1983	Other Private Secto Funding[1]
22	Coal Combustion Systems	41.0	6.5	45	48	Comparable
23	Heat Engines & Heat Recovery	15.4	0.0	0	0	More
24	Fuel Cells	34.5	9.5	21	24	Less
25	Buildings & Community Systems	47.7	0.0	18	22	Comparable
26	Industrial Conservation	28.8	0.0	11	14	Much More
27	Transportation Conservation	58.9	0.0	2	3	Much More
28	Multi-Sector Conservation	16.5	17.5	0	0	Comparable
29	Solar Applications for Buildings	96.1	27.0	3	4	Less
30	Solar Applications for Industry	53.0	18.0	0	0	Much Less
		$391.9	$ 78.5	$100	$115	

---

[1] Relative to the sum of DOE, EPRI and GRI budgets.

improved, environmentally acceptable combustion systems to replace oil and natural gas in the industrial and utility sectors with coal and coal-based fuels. The program supports four activities: atmospheric fulidized bed combusion (AFB); pressurized fluidized bed combustion (PFB); advanced combustion technology; and alternative fuel utilization. AFB technology is in the early stages of commercialization. There is a reasonable prospect that the private sector will carry the work further, but some continued government participation is required on large scale plants for utility applications. PFB technology is at the pilot plant stage, and probably several years from commercialization, given adequate support. The last two are engineering and technology activities on the potential use of coal-based slurry fuels as a replacement for oil in new and existing utility and industrial applications.

Private sector R&D is mainly supported by the regulated segment (utilities) and by equipment manufacturers. As in programs 13-16, these users are best able to discern the most attractive R&D targets. Here too, commercial technology does exist, and furthermore, retrofitting improvements are an important consideration. As a result, private sector involvement is most important.

Although the private sector R&D is rated high, the Federal role here remains one of substantial financial support to assure rapid progress on a pressing national problem. The policy risks (i.e., the uncertainties of environmental regulation and of government oil import policies) are the determinants of the Federal involvement, which should remain significant until switching from oil and gas to coal is no longer blocked by economic and technological limitations. The appropriate Federal role is complementary. However, in the area of research on acid rain, which is believed to be related mainly to the combustion of fossil fuels, the Federal role is primary. One would expect DOE to have a major role in establishing and executing this multi-year R&D program. However, this is not the case, and ERAB notes this fact with concern.

2. Heat Engines and Heat Recovery

The goal of this program is to provide advanced stationary power systems that can utilize noncritical fuels such as coal, coal-derived liquids and gases, residual petroleum and waste heat. DOE has proposed to phase out this work entirely, while the ERAB report on priorities recommended continued funding for selected subjects. It is not known how much of this work will be continued by private industry, or how rapidly, but commercialization will be considerably slower (or delayed indefinitely) than would have been the case of with Federal funding. One must also recognize the very high cost of developing full-size machines for operation at the hoped-for high temperatures. This constitutes a financial risk beyond the reach of most manufacturers. Co-funding may again be the very best way to assure proper selection of R&D projects, but until success is assured, the Federal role remains complementary.

3. Fuel Cells

Fuel cells have been the subject of increased R&D support over the last 30 years. Until quite recently, application had remained limited to certain small-scale users in the space program and by the military.

However, two major test programs are currently in progress, co-funded by industry and DOE, which could have a major impact on the future market for this type of converter.

There is no question about the unique advantage fuel cells ofer in terms of environmental impact. They are uniquely benign in every respect (emissions, noise, water requirement, etc.). They are also highly efficient converters of (fossil) chemical energy to electricity. Fuel cells could therefore have a profound effect on energy efficiency and on environmental concerns in virtually all areas of energy use, including power generation, space conditioning, and transportation.

The Federal R&D support on fuel cells has been a major factor in bringing the program to the present threshold of commercial acceptance. It is important that this support be continued until commercial viability is determined. ERAB views the Federal R&D role to be complementary for this program. Without Federal support, it is safe to conclude that commercialization would be delayed considerably or would not take place.

4. Buildings and Community Systems

This program is intended to accelerate the rate of improvements in the energy efficiency of buildings, community systems, consumer products, etc. Building system R&D is both long-term and high risk in the areas of ventilation and controls, envelope systems and materials, performance calculations and diagnostics, space conditioning and lighting, energy conversion equipment, pilot projects, and case studies. The Residential

Conservation Service requires states and utilities to provide conservation information to consumers, offer home energy audits, and make arrangements for installing and financing conservation measures. Community systems R&D analyzes all energy production and consumption in a community and devises cost effective alternative technologies. Technology and Consumer Products R&D is intended to accelerate the introduction of efficient heating and cooling equipment and appliances. The Federal Energy Management Program is intended to increase the energy efficiency and reduce the energy consumption of Federal Government facilities and operations. The January, 1983 ERAB Report on Conservation discusses this program in detail. This is an area of major potential savings, where very little is being done. The Federal role is obviously primary. Urban Waste R&D is on the production of energy, the recovery and reuse of materials and energy, and the conservation of energy in municipal waste systems. The FY 1983 DOE budget provides no funding for these activities.

The potential dollar benefits of relatively small improvements in the energy efficiency of building envelopes, HVAC systems, appliances, and lighting are substantial, as would be the savings in oil and natural gas. However, the building industry is dominated by small firms, even the largest of which are incapable of carrying out R&D at the levels required. Also, there is little incentive to support R&D, as many of the resulting improved techniques, materials, etc., would be difficult to patent and therefore provide no competitive advantages to the developer. Further, private firms have little incentive to conduct R&D on the potential human health and safety risks of construction materials and techniques, which may be signficant (e.g., indoor pollution resulting from reduced air infiltration and from urea formaldehyde insulation).

Therefore, due to a combination of the above-noted factors involving Building and Community Systems activities ERAB concludes that Federal support is necessary if the benefits are to be achieved in a reasonable time period. A primary Federal role is indicated for R&D supporting the building industry.

5. Industrial Conservation

This program seeks to improve the efficiency of industrial energy use. The major activities are R&D in support of waste energy reduction, industrial process efficiency improvement, and industrial cogeneration. The DOE program has resulted in a variety of successful demonstrations, now being adopted by industry.

The industrial sector is extremely diverse, and it is difficult to make any useful generalizations about it. One cannot even assume that industry will always respond efficiently to prices, or that it has the technical ability to develop energy saving processes or products. The evidence is clear, however, that while a few industries have done very well in energy conservation, others have failed to invest in even the simplest conservation measures with proven high payoffs.

Of the heavy energy-consuming industries, only the petroleum refining and chemical industries do a significant amount of R&D, including R&D on energy conservation, and certain large firms in other industries support conservation R&D programs. It is not apparent however, where funding will come from for major process improvements which are assumed to be necessary for many of the U.S. industries composed of small entities. This being the case, a Federal role is envisioned to undertake exploratory R&D in generic high-risk process improvements and other energy-conserving areas. However, to assure a well-directed program with a good chance for commercial acceptance, private industry will have to take the lead with a supporting, complementary, Federal role.

6. Transportation Conservation

The major activities under this program are surface vehicle propulsion RD&D and electric and hybrid vehicle RD&D. Smaller activities are transportation systems utilization and alternative fuels utilization. The program goals are to reduce energy use and to reduce the dependence of transportation on petroleum as a fuel. The FY 1983 budget provides no funding for these activities.

Market forces have brought about major technology improvements in recent years that will result in major energy savings in the future, but further R&D can result in additional fuel savings and economic benefits. We note that R&D in this area also has important potential national security benefits due to the predominant use of petroleum fuels by DOD. There is no reason to doubt that the transportation industry will continue to conduct R&D to achieve incremental improvements in efficiency. We therefore assign a minimal Federal role.[1]

7. Multi-Sector Conservation

This program consists of three activities: 1) the appropriate technology small grants activity provides funds for the development, demonstration, and commercialization of alternative energy efficient devices; 2) the inventor's program, which provides direct support to inventors by evaluating their inventions, providing technical and financial assistance, and assisting in the commercializtion process; and 3) energy conversion and utilization technologies (ECUT), which is basic and applied research in support of the other conservation R&D programs. ECUT is quite broad, including work on new insulation materials, advanced closed cycle power systems and industrial furnaces, improved heat exchanger materials, advanced technologies for the biological conversion of wastes, improved internal combustion engines, and many other topics. The FY 1983 DOE budget provides funding only for the ECUT activity. We agree with the Administration's position that appropriate technology and the inventor's program are properly private sector roles. Both of these are supported through the Small Business Development Act of 1982, which clearly established a Federal Government role of fostering technological innovations and private sector commercialization by funding research and development activities of small businesses.

---

[1] ERAB notes that R&D on longer term objectives such as high temperature materials, tribology and advanced batteries that may have applications in more than one program deserves continued Federal support. However, this work would be more appropriate under the technology base programs.

The R&D supported under ECUT is generally of a longer-term nature, applicable to many end-use sectors and ultimately promising high payoffs. A complementary Federal role is justified because either the industrial structure to support the R&D does not exist, or the benefits would be widespread and not profitable to the industrial sponsor.

8. Solar Applications for Buildings

This program consists of three activities: active solar heating and cooling, passive and hybrid solar energy, and photovoltaics. The DOE program objective is to accelerate the rate at which solar energy produces a significant amount of energy for buildings in the United States. The DOE FY 1983 budget provides funding only for the photovoltaics activity.

Active solar heating and cooling provides support to the heating, ventilating and air conditioning industry and research laboratories for basic and applied research, development and prototype system testing of advanced solar cooling systems, solar assisted heat pumps and solar ponds. Passive and hybrid solar energy provides support to the building industry for research, development and systems testing of advanced passive cooling systems, and for advanced passive components and materials.

Tax incentives are available for solar heating. The private sector has undertaken commercial activities, including R&D, and a minimal Federal role is adequate. There are appropriate areas for a Federal role in R&D in solar cooling, and passive and hybird solar. As noted under Buildings and Community Systems, the building industry is highly fragmented, and not capable of carrying out significant R&D.

We suggest that the DOE Buildings and Community Systems conservation program should be combined with the Active and Passive Solar Applications for Buildings program.. This would allow a much more integrated, coordinated and effective effort toward achieving the overall goal.

A photovoltaics industry exists, although the product is not competitive except in small, specialized markets. Significant possibilities for increasing efficiency lie with other solar photovoltaic technologies, where much R&D remains to be done. Specific Federal R&D recommendations will be found in the ERAB Solar R&D Report. The Federal role is complementary.

9. Solar Applications for Industry

This program is being reoriented by DOE to eliminate development and demonstration work on central receivers and distributed receivers and to concentrate on basic research to expand the technology base for solar thermal energy.

The Federal Government has expended considerable funds on the development and demonstration of central receiver systems. These systems are unlikely to be commercialized unless the Government follows through by funding the operation of major demonstration projects to collect, evaluate, and disseminate systems test data on plant performance and operating characteristics. Industry will be unwilling to invest in commerical plants until such data is collected and made available. Therefore, a Federal role is essential to ensure transfer of the technology. There is also a Federal role in conducting generic research to develop a better technology base for solar thermal technologies, including reflective and ceramic materials, system level controls, and concentrator designs. Overall, the appropriate Federal role in this area is minimal.

C. SUMMARY AND CONCLUSIONS

As noted in the ERAB Conservation Report, market prices do not call forth all conservation measures or R&D that are economically justified. The private sector, for reasons noted above, does not or cannot provide sufficient support for many projects that meet the criteria justifying a Federal role. In several cases, such as the building industry, there is little ability or incentive to conduct R&D. The Department of Energy, in making decisions on which conservation and improved end-use technologies to support, should take care to carefully analyze the sector of the economy that is involved rather than relying on generalizations which are frequently inaccurate in specific cases.

The Conservation Report also discussed R&D by the Government on its own behalf as an energy consumer. Where the Government is the sole buyer or maker of a product, such as in uranium enrichment, R&D to improve energy efficiency must be carried out by the Government, or it simply will not be done. Where the Government is a significant buyer, as of heating and lighting equipment, R&D will not only increase the efficiency of its own operations, but will also benefit the private sector. Thus, the R&D is justified as an investment that will be returned in tax dollars saved. Finally, where the Government is one of many buyers, and efficiency improvements are left to the vendors, it is failing as a steward of tax dollars if it does not stimulate such improvemens by refusing to buy energy inefficient products.

TABLE 5

CONSERVATION AND IMPROVED END-USE TECHNOLOGY

THE APPROPRIATE FEDERAL ROLE BASED ON SELECTED SUBCRITERIA

PROGRAM	SUBCPITERIA						Criterion: "Appropriate Federal Role" a/
	Private Funding Relative to Requirement	Time of First Pay-Off	Degree of Risk			Federal Role: Regulatory, Environmental or Policy Needs	
			Technical	Market	Policy		
CONSERVATION AND IMPROVED END-USE TECHNOLOGY							
22 Coal Combustion Systems	Medium	Intermediate	Medium	Medium	High	High	Complementary
23 Heat Engines & Heat Recovery	Low	Intermediate	Medium	High	Low	Low	Complementary
24 Fuel Cells	Medium	Intermediate	Medium	High	Low	Low	Complementary
25 Buildings & Community Systems	Low	Near	Low	High	Low	High	Dominant
26 Industrial Conservation	Low	Near	Medium	Medium	Low	Medium	Complementary
27 Transportation Conservation	High	Near	Medium	High	Low	High	Minimal
28 Multi-Sector Conservation	Low	Intermediate	High	High	Low	Low	Complementary
29 Solar Applications for Buildings	Medium	Intermediate	Medium	High	High	Low	Complementary
30 Solar Applications for Industry	Low	Intermediate	High	High	High	Low	Minimal

a/ Rankings do not indicate priorities.

CHAPTER V

TECHNOLOGY BASE

A. Discussion

As noted in Chapter I, the technology base programs are inherently long-term in character and high risk in terms of being able to identify the practical consequences of any individual project. It has therefore been long established that the Federal Government must play a primary role in the support of the important research programs that contribute to new understandings and to expansion of the technology base. These programs focus on exploring and understanding the fundamental laws of nature, and on the properties of matter and living systems. In fact, the Federal Government does support most of the basic research in the United States. The private sector generally concentrates on applied research and development, as in most cases it would be difficult to recover expenditures on technology base research.

The basic research programs supported by the Department under the technology base are:

31. Energy Supporting Research

Basic Energy Sciences

- o Nuclear Science
- o Materials Science
- o Chemical Sciences
- o Engineering, Mathematics and Geosciences
- o Advanced Energy Projects
- o Biological Energy Sciences
- o CO_2 and Climate Research

Technology Assessments

University Research

32. General Science

High Energy Physics

Nuclear Physics

Nuclear Medicine

33. Environment, Safety and Health

34. Biological and Environmental Research

The ERAB report on Federal Energy R&D Priorities gave strong support to these basic research programs. This report confirms ERAB's support, and assigns an overall primary Federal role to the technology base programs.

APPENDIX A

CHARGE LETTER

Department of Energy
Washington, D.C. 20585

ENERGY RESEARCH ADVISORY BOARD

JUL 9 1982

Dr. William McCormick
President
American Natural Resources System
One Woodward Avenue
Detroit, Michigan 48226

Dear Bill,

As we discussed at the Board meeting earlier this month, while the R&D Panel report adopted by the Board in November 1981 included the "Federal Role in Energy R&D" as one of its evaluation criteria, the interpretation of this criterion was not made separately for each R&D program area. It has become clear to me that the determination of the proper Federal role has been central to every subject that the Board has addressed and, thus, a more in-depth study of this topic is needed.

Given your able service as Vice Chairman of the R&D Panel, I would like to ask you to lead a working group of ERAB members and panelists to prepare a paper that would develop further our views on this important matter. I think that we all recognize that the appropriateness of Federal involvement in particular areas of energy R&D varies from technology to technology and industry to industry, so it would be necessary to examine both the broad end-use markets and the specific technologies intended to serve them, perhaps along the framework of the previous report. Much of the effort of the ongoing panels on Solar and Conservation R&D is devoted to defining the Federal role. In addition, the Multiprogram Laboratory Panel is addressing the role of federally sponsored laboratories. These activities, as well as several other past ERAB studies touching on the Federal role in energy R&D, can provide useful input to your work.

I have asked Roland Schmitt, Eric Reichl, Dayton Clewell, Floyd Culler, Henry Linden, Vicki Tschinkel and Grant Thompson to assist you and I will be glad to participate myself. It would be desirable to have a working draft for discussion at the September ERAB meeting with the intent to have a close-to-final product for consideration at our November meeting. This effort should provide the Board with an opportunity to draw together guidelines that would be helpful to Federal policymakers at many levels as plans and programs go through the inevitable process of change.

Sincerely,

Louis H. Roddis, Jr.
Chairman
Energy Research Advisory Board

APPENDIX B

ENERGY RD&D PROGRAM BUDGET SUMMARY

APPENDIX B
DOE BUDGETS

	Actual Obligations FY 1981	President's Request (March) FY 1982	ERAB Recommendations[1] (in $ millions)	Congressional Appropriation FY 1982	Request to Congress FY 1983
ELECTRIC-RELATED SUPPLY					
1. Magnetohydrodynamics (FE)	$ 67.0	$ 0	$ ZERO	$ 27.8	$ 0
2. Geothermal (CE)	156.0	46.8	LESS	53.5	9.8
3. Hydropower (CE)	3.2	0	ZERO	3.0	0
4. Electrical Energy Systems & Energy Storage Systems	111.7	47.5	LESS	58.5	0
5. Solar Power Technology (CE)	112.1	19.4	LESS	53.2	5.5
6. Magnetic Fusion (ER)	394.1	456.1	LITTLE LESS	453.8	444.1
7. Uranium Resource Assessment (NE)	30.7	5.8	SAME	10.0	3.0
8. Uranium Enrichment (NE)					
a. Centrifuge (NE)[2]	72.1	64.5	SAME	87.2	94.5
b. Advanced Isotope Separation (NE)	79.7	85.2	SAME	85.7	34.2
9. Conventional Reactor Systems (NE)	82.9	68.0	MORE	96.3	32.0
10. Breeder Reactors (NE)					
a. Liquid Metal Fast Breeder	367.7	367.8	SAME	391.3	270.8
b. Clinch River Breeder	172.0	254.0	LESS	193.9	252.5
c. Light Water Breeder	60.2	58.0	LESS	52.0	42.0
d. Fuel Cycle R&D	47.5	26.1	LITTLE LESS	37.5	36.8
11. Nuclear Waste					
a. Commercial (NE)	188.8	227.6	SAME	210.0	265.5
b. Defense (DP)	303.6	390.0	SAME	364.9	517.8
12. Mining R&D (FE)	33.9	21.0	LESS	11.0	1.0
Subtotal	$2,283.2	$2,257.8		$2,189.4	$2,009.5
LIQUIDS AND GAS-RELATED SUPPLY					
13. Advanced Technology (FE)	$ 99.2	$ 94.5	SAME	$ 81.4	$ 28.4
14. Coal Liquefaction (FE)	339.7	105.2	LESS	228.4	26.2
15. Surface Coal Gasification (FE)	70.1	53.4	LESS	53.1	10.5
16. In Situ Coal Gasification (FE)	10.1	8.3	LESS	8.3	0.7
17. Enhanced Oil Recovery (FE)	16.2	20.1	LESS	15.5	5.3
18. Enhanced Gas Recovery (FE)	30.1	10.2	LESS	11.5	0
19. In Situ Oil Shale (FE)	32.1	16.2	LESS	18.2	6.3
20. Biomass Energy (CE)	31.7	20.5	SAME	20.5	6.6
21. Alcohol Fuels (CE)	18.0	10.0	SAME	10.0	2.9
	$ 647.2	$ 338.5		$ 446.9	$ 86.9

TE: Figures not adjusted for deferrals, recessions or general reductions. Program Direction excluded.
Compared to President's March Request.

APPENDIX B
DOE BUDGETS
(Continued)

	Actual Obligations FY 1981	President's Request (March) FY 1982	ERAB Recommendations[1] (in $ millions)	Congressional Appropriation FY 1982	Request to Congress FY 1983
CONSERVATION & IMPROVED END-USE UTILIZATION					
22. Coal Combustion Systems (FE)	$ 37.7	$ 3.8	SAME	$ 41.0	$ 6.5
23. Heat Engines & Heat Recovery (FE)	29.2	15.6	SAME	15.4	0
24. Fuel Cells (FE)	32.0	28.6	SAME	34.5	9.5
25. Buildings & Community Systems (CE)	91.3	28.0	MORE	47.7	0
26. Industrial Conservation (CE)	69.6	0	MORE	28.8	0
27. Transportation Conservation (CE)	105.0	37.0	SAME	58.9	0
28. Multi-Sector Conservation (CE)	26.5	17.5	SAME	16.5	17.5
29. Solar Applications for Buildings (CE)	228.0	84.7	SAME	96.1	27.0
30. Solar Applications for Industry (CE)	138.3	44.0	LESS	53.0	18.0
Subtotal	$ 757.6	$ 294.2		$ 391.9	$ 78.5
TECHNOLOGY BASE					
31. Energy Supporting Research (ER)					
a. Basic Energy Sciences					
aa. Nuclear Science[2]	33.7	37.7	SAME	36.7	38.2
ab. Materials Science	96.5	112.1	MORE	104.7	120.2
ac. Chemical Sciences	67.1	73.9	MORE	68.6	75.9
ad. Engineering, Math & Geosciences	25.9	32.3	SAME	26.9	33.0
ae. Advanced Energy Projects	6.7	8.2	SAME	7.7	8.6
af. Biological Energy Sciences	7.7	9.4	MORE	8.9	9.9
ag. CO_2 and CLimate Research	12.5	16.7	MORE	14.6	9.3
b. Technology Assessments	9.5	3.0	SAME	3.0	2.6
c. University Research	11.8	10.6	MORE	10.6	5.1
32. General Science (EB)					
a. High Energy Physics	352.2	392.7	SAME	364.5	429.0
b. Nuclear Physics[2]	110.2	112.9	SAME	118.4	123.2
c. Nuclear Medicine	43.3	50.5	SAME	47.4	39.0
33. Environmental and Safety	54.1	49.6	SAME	49.5	39.0
34. Biological & Environ. Research (ER)	150.1	153.8	MORE	147.5	117.6
Subtotal	$ 981.3	$ 919.6		$1,009.0	$1,050.6
TOTAL	$4,669.3	$3,710.1		$4,037.2	$3,225.5

APPENIDX C

1982-1986 ELECTRIC POWER RESEARCH INSTITUTE R&D BUDGET

APPENDIX C

1982-1986 ELECTRIC POWER RESEARCH INSTITUTE R&D BUDGET
(Using ERAB Budget Categories)

$ MILLIONS

	1982	1983	1984	1985	1986	TOTAL 1982-1986
A. ELECTRIC-RELATED SUPPLY						
1. Magnetohydrodynamics (FE)	--	--	--	--	--	(a)
2. Geothermal (CE)	3	4	5	6	7	25
3. Hydropower (CE)	1	1	1	1	1	5
4. Electric Energy Systems and Energy Storage Systems	47	54	68	86	96	351
5. Solar Power Technology (CE)	4	6	7	8	9	34
6. Magnetic Fusion (ER)	2	3	3	3	3	14
7. Uranium Resource Assessment (NE)	--	--	--	--	--	(a)
8. Uranium Enrichment(NE)	--	--	--	--	--	(a)
a. Centrifuge (NE)						
b. Advanced Isotope Separation (NE)						
9. Conventional Reactor Systems (NE)	56	60	67	70	81	334
a. Supplemental Program	25	5	--	--	--	30
10. Breeder Reactors (NE)	2	3	5	5	10	23
a. Liquid Metal Fast Breeder						
b. Clinch River Breeder						
c. Light Water Breeder						
d. Fuel Cycle R&D						
11. Nuclear Waste	1	2	3	5	5	16
a. Commercial (NE)						
b. Defense (DP)						
12. Mining R&D (FE)	--	--	--	--	--	--
SUBTOTAL	141	138	157	184	212	832
B. LIQUID &-GAS RELATED SUPPLY						
13. Advanced Technology (FE)	--	--	--	--	--	--
14. Coal Liquefaction (FE)	12	13	7	11	11	54
15 Surface Coal Gasification (FE)	27	24	21	12	15	99
16. In-Situ Coal Gasification (FE)	--	--	--	--	--	--
17. Enhanced Oil Recovery (FE)	--	--	--	--	--	--
18. Enhanced Gas Recovery (FE)	--	--	--	--	--	--
19. In-Situ Oil Shale (FE)	--	--	--	--	--	--
20. Biomass Energy (CE)	--	--	--	--	--	(a)
21. Alcohol Fuels (CE)	--	--	--	--	--	--
SUBTOTAL	39	37	28	23	26	153

APPENDIX C

1982-1986 ELECTRIC POWER RESEARCH INSTITUTE R&D BUDGET
(Using ERAB Budget Categories)

	$ MILLIONS					
	1982	1983	1984	1985	1986	TOTAL 1982-1986
C. CONSERVATION AND IMPROVED END-USE UTILIZATION						
22. Coal Combustion Systems (FE)	45	48	58	71	87	309
23. Heat Engines & Heat Recovery (FE)	--	--	--	--	--	--
24. Fuel Cells (FE)	9	9	12	15	16	61
25. Buildings & Community Systems (CE)	5	7	8	10	10	40
26. Industrial Conservation (CE)	3	4	5	5	8	25
27. Transportation Conservation (CE)	2	3	3	3	7	18
28. Multi-Sector Conservation (CE)	--	--	--	--	--	--
29. Solar Applications for Build. (CE)	--	--	--	--	--	(b)
30. Solar Applications for Ind. (CE)	--	--	--	--	--	(b)
SUBTOTAL	64	71	86	104	128	453
D. TECHNOLOGY BASE						
31. Energy Supporting Research (ER)[d]	7	7	9	10	13	46
a. Basic Energy Sciences						
aa. Nuclear Science						
ab. Materials Science						
ac. Chemical Sciences						
ad. Engineering, Math & Geosciences						
ae. Advanced Energy Projects						
af. Biological Energy Sciences						
ag. CO_2 and CLimate Research						
b. Technology Assessments						
c. Univeristy Research						
32. General Scinece (ER)	--	--	--	--	--	--
a. High Energy Physics						
b. Nuclear Phyusics						
c. Nuclear Medicine						
33. Environment and Safety (EP)	--	--	--	--	--	(c)
34. Biological & Environmental Research	24	27	30	34	36	151
SUBTOTAL	31	34	39	44	49	197
TOTAL	275	280	310	355	415	1,635

(a) Nominal Amount
(b) Included in #25, 26
(c) Nuclear safety included in #9, fossil environmental control included in #22
(d) Additional amounts reflectted throughout EPRI program

APPENDIX D

1982-1986 R&D BUDGET

GAS RESEARCH INSTITUTE

APPENDIX D

1982-1986 GAS RESEARCH INSTITUTE AND R&D BUDGET
(Using ERAB Budget Categories)

$ MILLIONS

	1982	1983	1984	1985	1986	TOTAL 1982-198
B. LIQUID &-GAS RELATED SUPPLY						
13. Advanced Technology (FE)						
14. Coal Liquefaction (FE)						
15 Surface Coal Gasification (FE)	7.0	7.0	8.0	12.5	16.9	51.4
16. In-Situ Coal Gasification (FE)	1.0	---	0.5	1.0	1.0	3.5
17. Enhanced Oil Recovery (FE)						
18. Enhanced Gas Recovery (FE)	11.0	18.9	24.1	27.9	32.2	114.1
19. In-Situ Oil Shale (FE)						
20. Biomass Energy (CE)	9.4	9.3	6.9	8.6	9.2	43.4
21. Alcohol Fuels (CE)						
22. Gas Energy Systems Energy Storage Systems[a]	7.3	7.3	8.6	11.2	11.9	46.3
SUBTOTAL	35.7	42.5	48.1	61.2	71.2	258.7
C. CONSERVATION AND IMPROVED END-USE UTILIZATION						
22. Coal Combustion Systems (FE)						
23. Heat Engines & Heat Recovery (FE)	11.9	19.4	21.9	30.6	28.8	112.6
24. Fuel Cells (FE)	12.4	19.5	19.0	7.6	5.6	64.1
25. Buildings & Community Systems (CE)	9.4	14.9	15.2	19.5	20.4	79.4
26. Industrial Conservation (CE)	4.6	7.8	9.0	11.2	12.6	45.2
27. Transportation Conservation (CE)						
28. Multi-Sector Conservation (CE)						
29. Solar Applications for Build. (CE)						
30. Solar Applications for Ind. (CE)						
SUBTOTAL	38.3	61.6	65.1	68.9	67.4	301.3
D. TECHNOLOGY BASE						
31. Energy Supporting Research (ER)	8.6	10.6	11.4	11.9	11.9	54.4
a. Basic Energy Sciences (non-add)	(7.7)	(9.2)	(9.8)	(10.0)	(10.0)	(46.7)
b. Technology Assessments						
c. University Research						
32. General Science (ER)						
33. Environment and Safety (EP)	1.1	1.7	1.8	1.3	1.5	7.4
34. Biological & Environmental Research						
SUBTOTAL	9.7	12.3	13.2	13.2	13.5	61.8
TOTAL	83.7	116.4	126.4	143.3	152.0	621.8

---

[a] Reflects gas distribution and storage R&D.

Mr. **Fuqua**. Mr. Thompson, you discussed on page 10 of your prepared statement some of the things that the Board concluded that an energy management system for the Federal Government needed to insure success. No. 1 was that there must be top management commitment and support. Do you feel that, in the field of conservation, at the top management, there is commitment and support for the program?

Mr. **Thompson**. It's an interesting subject. We had the benefit of briefings by top energy conservation managers of some of America's largest corporations, and a number of them said to us that in the last several years that the pressures even within their own companies had fallen because there seemed to be a less intense national commitment to energy conservation. Energy conservation is part technology, part response to price, and part behavioral changes. One of the important behavioral changes clearly is the feeling that the people at the top care about it and mention it in media broadcasts they make. There certainly was a feeling by the people who briefed us that there had been much less of that in the last few years.

Mr. **Fuqua**. In your statement, though, you were referring to the Federal Government. I'm referring to DOE, particularly.

Mr. **Thompson**. One can look at that in a number of ways; if you look at personnel cuts, if you look at budget cuts, if you look at the areas where commitment is translated into action, I think it would be hard to argue that management commitment has been as strong there as it has been in the past.

Mr. **Fuqua**. Vicki, your ERAB report on solar recommended funding for the parabolic dish technology, due to its potential for higher efficiencies and lower cost. What was the basis or rationale for that recommendation and what is your reaction to the fact that no funds are provided in the DOE fiscal year 1984 request for the parabolic dish technology?

Ms. **Tschinkel**. I can't explain why there are no funds in the proposed budget. You would have to ask the Department for that. Our rationale was that, I believe, the net efficiency for the parabolic dish was about 26 percent when combined with a Stirling engine at its focus, and it's an extremely promising technology. I think if you compare the development of other solar thermal technologies as they have gone into the marketplace, there has been a time in between the discovery of the possibility of efficiency as developed and the ability of industry to move forward. A time when the machines have to be tested linked up—one of the important things about it is its modularity. That's why we recommended a cost-shared program with industry in this field. We think its very promising; we think its very likely that industry would not move forward significantly without a little nudge.

Mr. **Fuqua**. You mentioned that it was the conclusion of your Panel that if we did not have approximately fiscal year 1982 funding then the large-scale demonstration programs such as MOD-5 would have to cease and we would have to concentrate on the more basic technology development and proof of concept experiments. I've been juggling with some figures and we are trying to maintain 1983 levels, not even 1982 levels, and the 1984 request is considerably below the 1983 level. What do you think about continuing MOD-5 demonstration based on a 1983 budget level?

Ms. **Tschinkel**. Well, although the report mentioned the 1982 budget as a basis, because that's what we had available to us at the time we made our recommendations, as you are probably aware, we were talking about a budget in the neighborhood of $200 to $250 million when we made that recommendation, if that helps to focus in on that.

Mr. **Fuqua**. Of course, it's considerably lower than that in the DOE request for 1984.

Ms. **Tschinkel**. In the proposed budget, yes, sir.

Mr. **Fuqua**. Do you think under the 1983 budget there would be enough money for the continuation of the demonstration of the MOD-5? We're so close to completing the program.

Ms. **Tschinkel**. Mr. Chairman, if I understand what the 1983 budget was that was finally appropriated, that was certainly within the figure where we thought there was room for the MOD-5.

Mr. **Fuqua**. You also discussed the OTEC program. Once the pilot plant and the preliminary design work are completed, what would you propose that we do with that program? You did raise some questions about not demonstrating it further.

Ms. **Tschinkel**. We thought that some work ought to continue to look at materials for the shore and shelf phase, cold water pipes, the heat exchanger. There still seem to be some theoretical questions a little bit parallel to those with wind in the sense of understanding the graphics of the environment in which it operates and the behavior of the plume and so forth. We thought those areas certainly ought to be continued.

Mr. **Fuqua**. Mr. Thompson, in your Panel you recommended research on advanced cogeneration systems and some generic industrial process efficiency improvements, neither of which are included in the fiscal year 1984 budget request. What did you have in mind about those projects and why did your Panel consider them important?

Mr. **Thompson**. We considered them important—those kinds of programs—because, in our view, there is a great misunderstanding about the nature of industry conservation research. It's easy to say "industry" and to get into one's mind a rather monolithic view of large, well funded, well researched, large research capability—the Du Ponts and General Motors kind of area.

In fact, American industry is characterized by a great deal of diversity, and the industrial processes and the cogeneration R&D that we support would be widely used in very small fragmented industries that themselves have no R&D capability. I think, for example, of the paper industry. I think of the textile industry. They simply have no way to adopt the new high technologies, to invent new high technologies, to permit them to survive in a world competitive situation.

I think, for example, of steel which is a large industry, but an industry of no great health, where some of the laser technologies that grew out of the space program have been adopted for looking at the surface of hot steel ingots as they come out, permitting you to tell whether they are of sufficient fineness for certain purposes. In the past you had to let them cool down, examine the surface, and if they were, then reheat them and use them. The process grew out of some cofunding by the Department some years ago. It's that kind of work which assists the fragmented industry, or the industry that has no internal R&D capability that we had in mind.

It seems to me, speaking personally, that the industrial health of this Nation, and our ability to compete against some of our vigorous world competitors, who value Government cost-shared R&D, perhaps higher than we do, it seems to me a worthy call on the Nation's budget.

Mr. FUQUA. Vicki, I can't let this opportunity go by without mentioning the great conservation program that we have at Eastpoint that I need to talk to you about.

She licenses all the environmental programs in Florida and does a very excellent job.

Mr. Winn.

Mr. WINN. Thank you, Mr. Chairman.

Dr. Bennett, the Panel has recommended an extension of the business energy tax incentives, as I understand it. At what level do you believe that it would be appropriate to continue these credits?

Dr. BENNETT. I would like to refer that to Ms. Tschinkel.

Ms. TSCHINKEL. We didn't make a recommendation as to the level or look into the degree of what level would affect industry in what way. The only thing I can say is that almost without exception, industrial testimony and other testimony that we had was that the solar industry would simply not be able to pick up its responsibilities, or even exist at the current levels without them. They did feel that a phase down, as long as it was sufficiently far in advance and well understood by everyone, could probably be accommodated. I really can't give you anymore advice than that.

Mr. WINN. How long a period of time do you think you are talking about?

Ms. TSCHINKEL. We recommended about 4 years.

Mr. WINN. So, if we want to phase it out right now and turn it over to industry, we had better put them on notice about it sometime soon, shouldn't we?

Ms. TSCHINKEL. Yes, sir. Of course, we recommended the phase down not begin until 1986.

Mr. WINN. Let's go back. If the extension of the business energy tax incentives were made, do you believe it would still be necessary to provide onbudget R&D support at current levels, lower levels, or what?

Ms. TSCHINKEL. I think that——

Mr. WINN. This may not be a recommendation of your ERAB Panel, but more your own personal opinions.

Ms. TSCHINKEL. Actually we did look at that, and we generally found that a budget level in the neighborhood of, as I said, between $200 and $250 million approximately would allow a steady, not particularly rapid, but a steady improvement in the solar deployment in this country when coupled with the tax recommendations we made.

Mr. WINN. Mr. Thompson, in your testimony you indicate that DOE should continue to support the conservation R&D program, especially in the buildings and the industrial areas. You also allude to some of the imperfections in the marketplace that serve to reinforce the need for Federal support. What are some of the institutional barriers? I'm interested to know, as a former builder, what are some of the institutional barriers that must be overcome in order to stimulate conservation related activity. For example, streamlining Federal patent laws, clarifying antitrust laws—are those the types of thing that might be involved?

Mr. THOMPSON. We were talking about those kind of areas in which the cost of energy is not felt by the person who makes the decision. As you know, the market model is that at the time of making a decision one looks at the total cost of what you are going to do and you say, well this refrigerator costs this much, but it costs so much more to run, and this one is cheaper to run, but it's a little more expensive. The market model suggests that you make your decision on the basis of that kind of "what's best for me in view of my own particular situation." In fact, that market model simply doesn't exist in many large segments of the economy. Let's take commercial buildings for example. Commercial buildings are typically built on speculation. All of the basic energy-consuming design features are cast in concrete, often literally, before the first lease is signed. Therefore a tenant who then faces a stream of energy costs which are unknown, because he or she signs the lease, frequently before the building is built, and before the first energy bill has been rendered, has no say in the decision on what kind of central space conditioner will be used, what kind of lighting will be used, what kind of insulation, or what kind of shading in the building. It was that kind of institutional barrier. Another example of an institutional barrier is the kinds of furnaces one buys in a new house. Real estate people say there are three things in selling a house: location, location, location. None of those have anything to do with what kind of furnace you have. Yet, the statistics are that something in the order of two-thirds of all furnaces are purchased by somebody other than the person who is going to pay the bill.

You buy the house and you are stuck with the furnace that comes with it. You didn't have a choice in that. When the decision on what kind of a furnace or what kind of insulation was made, you weren't present. Your interests weren't consulted. The National Association of Homebuilders did a survey of its members and asked members in buying appliances, that is, hot water and heating/air condition appliances, whether energy considerations were part of their decision on which models to buy. One would expect on that kind of survey where people respond voluntarily, to get socially acceptable responses. Of course, I worried about that. In fact, 61 percent said they didn't take energy considerations into account. Those are the kinds of institutional barriers that we had in mind.

Mr. WINN. In most cases you're talking about, or start out talking about, a speculative office building. Let's say that there are 10 units. If you're having a speculative office building you've got to give credit to the architect and to the builder. You can't have 10 different types of offices telling you what kind of solar units you're going to have in there. You would have a mishmash that would be unbelievable. The same thing in a speculative house. If the builder, and I used to be the vice president of the Home Builders Association, is going to pick that house he's going to pick something that he thinks is going to sell. I mean brand, if nothing else, or a highly advertised brand or a combination of both, with a good reputation and a good warranty and a good guarantee. You're really talking about the system more than anything else.

Mr. **Thompson**. That's right. But there are important things that Government can do. One that our report deals with is the question of providing new technologies. Americans are extremely inventive, and we're an extremely inventive, technologically exciting Nation. The Government has played an enormous role in that bubbling up of new technology. There's no reason we shouldn't expect that kind of bubbling up of new technology in conservation as well. But a builder, as you yourself would know, really often doesn't have the capital to take risks and has to have a certainty first that some new product really will work, so that he's not faced later with losses.

Mr. **Winn**. I wouldn't want to be the guinea pig.

Mr. **Thompson**. You wouldn't want to be the guinea pig, exactly.

And second, if it's really going to sell, if it's going to be much better for his purchaser, the builder would like some reliable certification that it's going to be better. So, both in helping create new products, where the market works poorly, but particularly in testing and in labeling and information, the Government has quite a role. You know, one of the things which has pushed us toward low tar cigarettes is the labeling. The simple information program.

One of the things which has dramatically helped move us on the road toward more efficient cars has been the EPA/Department of Transportation labeling. And our panel feels that there's important Government work to be done in development of information programs to help the consumer and to help the businessman who is trying to do right by his customers.

Mr. **Winn**. Thank you very much. I haven't had time to read your report but I look forward to reading it.

Thank you very much.

Thank you, Mr. Chairman.

Mr. **Fuqua**. Thank you, Mr. Winn.

Mrs. Schneider?

Mrs. **Schneider**. Thank you, Mr. Chairman.

Dr. Bennett, I wonder if you could please tell us how many members there are on the ERAB?

Dr. **Bennett**. Approximately 25.

Mrs. **Schneider**. Twenty-five. How long did it take you folks to put the report together?

Dr. **Bennett**. It took from April to September for Ms. Tschinkel. Grant, how long?

Mr. **Thompson**. I'm a lawyer. It took us a year.

Mrs. **Schneider**. Shame. And approximately how much did it cost the U.S. Government or the taxpayers to put this report together?

Dr. **Bennett**. I can get that information for you.

Mrs. **Schneider**. Just an approximate number would be all right.

Dr. **Trivelpiece**. It's difficult to come up with the costs of the time that's involved because most of the people who serve on ERAB serve without compensation. They provide their time free to the Government. There are some administrative costs that are associated with some of their transportation and paying their expenses. It's not a substantial cost, however, compared with the value of the work that they do.

Mrs. **Schneider.** I think I would agree with that, considering that we know we have at least one lawyer, and we know what their fees can be, and we have a doctor. So, I think that if we are to understand the voluntary investment in this report, it is significant. I have always felt that if any individuals are going to work very hard to produce a product and make recommendations to a particular agency, or to a particular individual, then certainly it is important that that agency look closely at it and respond to some very thoughtful, well studied recommendations.

The chairman had asked if there was a report, a systematic report, that you would be putting forward, and you mentioned on a case-by-case basis. I, for one, would be very interested in seeing your response to the recommendations that have been made insofar as personnel and management are concerned, and so far as conservation and solar. I think that one of the points that Mr. Thompson made—which, to put it very simply, is that we cannot afford to put all of our energy eggs in one basket—that is what I perceive to be one of the most significant bottom line messages coming out of that report. Yet, when one looks at the budget we see the antithesis of that. So, I can understand how we have gotten in this predicament because the previous Secretary of Energy's charge was to dissolve the Department of Energy. Now, I'm under the impression that the intentions to dissolve the Department are no longer there. As a result of this one direction at one moment and the other direction at the other moment, unfortunately, a large number of qualified personnel have been lost to the agency. I am anxious to see some kind of shift.

Mr. Thompson, I would like to ask, in relation to this, about the large number of qualified personnel that have left the agency, particularly at the senior management level. What do you think that DOE should do right now to provide the incentive or provide some encouragement to attract experienced senior program managers to both remain in the program, and if there is need for additional people, to implement some of these programs? How do you think one should go about doing it at DOE?

Mr. **Thompson.** I think it's interesting to look at some of the figures because they underline the nature of that problem. In their senior executive service in conservation in 1982, there were 12 SES employees, and planned in 1984 that's going to be down to 4. None of those four will be in the top three SES categories. Looking at GS-14's and GS-15's, the top manager within the Civil Service category, in 1982 there were 74, in 1984 it's planned to be down to 41. So, obviously, it's a real problem simply getting the management talent to carry out the kind of program that the board feels needs to be done.

I think to address your question of what needs to be done to make the remaining senior managers happy and productive and to attract new managers, it seems to me, are the kinds of things you need in any organization. That is a strong sense of leadership, which is committed to the program and is committed to the goals of the program, and it has a strong base of analytic ability to take the resources and deploy them effectively.

My impression of what is needed to help make the conservation program a happier and more productive place and attract senior management is a feeling that they have a job to do; that that job is supported and that people want that job to succeed.

Mrs. **Schneider**. What would you say so far as the Department of Energy is concerned in terms of reducing their own energy consumption?

Mr. **Thompson**. We had an interesting experience in this. The top energy conservation person of one of the large companies with office buildings all over the country came and gave a briefing to our panel, made an offer to us. The gentleman was walking through Forrestal on his way to lunch, and he looked around and afterward he said, this place is terrible. He said, look at the lights, feel the heat, look at the doors open. He said I'll bring four of my top energy auditors down and look at this place. It was interesting, that for whatever reasons, the Government turned down that offer of a free energy audit from one of the country's largest and most experienced users of energy.

Mrs. **Schneider**. To whom was the request made? Was it made to Secretary Hodel himself, do you know?

Mr. **Thompson**. I don't really know how it went up through the management.

Mrs. **Schneider**. Is there an opportunity to retrieve that offer, do you suppose?

Mr. **Thompson**. I think it might be worth trying.

Dr. **Trivelpiece**. The Forrestal Building is not under the control of the Department of Energy. It's a GSA building. So, it was not our prerogative to offer that service of that company. If the General Services Administration would like to have such an audit carried out then it would be between them and whoever this organization was.

Mr. **Thompson**. We, certainly, see that there are neither management resources in number of people, nor, if I could put it, organizational clout, for carrying out energy conservation programs within the Government. The Federal energy management program is buried a good number of layers down within the Department of Energy. It has, if I recall, something like five full-time employees. That group meets with an interagency committee which meets rather infrequently, the so-called 656 Committee, that is supposed to tell the General Services Administration to save energy. It's supposed to tell the Department of Defense, that uses 82 percent of the Government's energy, to save energy.

Mrs. **Schneider**. Eighty-two percent, did you say?

Mr. **Thompson**. Eighty-two percent. Principally jet fuel is their largest component of DOD's energy use. But, this five-person office well down within the bureaucracy to help manage energy seemed to our board not a very realistic organizational structure. The ERAB recommended that energy conservation management be raised to the OMB level, a level within the executive branch that has clout. And that departments be given line-item budgets for capital expenditures.

Mrs. **Schneider**. OK. Thank you.

I guess I can't help but respond that my constituents are very tired of recognizing that they should be saving their energy in school boards and school departments or attempting to save energy through energy efficiency measures and through energy conservation. It is rather mind boggling to the school boards and PTA organizations, and everybody else, when they come to Washington and they see the amount of waste that goes on. It's part of that old syndrome, you know, how dare we ask others to tighten their belt without tightening our own. So, I think that that's certainly something that the Government should lead by example.

The final question that I have has to do with information generation. I think that one of the greatest frustrations of many of my constituents is that they know there is technology out there, but they do not know where to find it, they don't know what the best available technology is. I think that particularly many of my businessmen who are trying to take energy efficiency measures by changing their manufacturing processes, or whatever, just don't know where to find the latest technology. I am not aware of your critique on information generation within DOE, and I wonder if you could please touch on that?

Mr. **Thompson**. We do talk about information transfer being an important component of a good R&D program. It certainly is not worth it to conduct research and development and then hide it under your hat. You simply shouldn't do it if that's your objective.

I might say, interestingly, that there's R&D to be done on information transfer itself. This is a subcategory of a broader issue that we raised on behavioral research, that is, looking at what motivates people to use and conserve energy.

There's been very limited research on what kind of information and how to present the information in a way which is meaningful to people. For example, in quite a different field, the Food and Drug Administration is now doing some experimentation on how best to present nutritional information to consumers on the sides of cake mixes and cereals to see what gives people the most useful information, that causes them to modify. In that same way, we really do need to know when can information be presented? How can it be presented in a way that causes people to understand what choices they have and what their own interests are? How frequently? Who's the best provider of information? These are all researchable questions. We know in general that information is good, but we ought to have it as good as possible.

Mrs. **Schneider**. Dr. Trivelpiece, did you want to comment on that? About how we get all the good work out to the public that you are disseminating information about all the work.

Dr. **Trivelpiece**. Certainly. Most of the research and development activities that the Department engages in have as their end product knowledge, teaching, that usually appears in the form of a report. Most of these reports are available through the Technical Information Center at Oak Ridge National Laboratory, and that information can be either obtained, in some cases when the reports are first delivered, if the individuals are on the mailing list free of charge, and in other cases they are requested to pay for the reports. By and large the information is available. It is not, perhaps, aggressively marketed, but it is at least passively available.

Mrs. **Schneider**. I guess that is one of the problems because the citizens don't even know where to look for information. The fact that it is available, I think, is the first step, and somehow or another there has to be some transfer developed.

Mr. **Thompson**. Our report addresses this specifically in which we say that the Government must be sensitive to the special needs of medium in small scale industries that do not have energy conservation expertise themselves, and we talk about the use of energy analysis in diagnostic centers with audit to improve housekeeping, and also to share results in workshops, newsletters, and seminars. I'm surprised at how frequently people who have gotten sufficiently obscure in their finding information resources and have found me still don't know about Oak Ridge. So I take it that, obscure though I am, that there's a level beneath me.

Mrs. **Schneider**. Could you tell me what page that was on that you were reading from?

Mr. **Thompson**. In the printed copy, which I have, it's on page 17 at the top of the left-hand column.

Mrs. **Schneider**. OK. Thank you.

Mr. Chairman, I regret that I have to go to another hearing, but I wonder if we might keep the record open to submit a few more questions in writing?

Mr. **Fuqua**. Yes; We'll be glad to.

Mrs. **Schneider**. Thank you. I thank you very much for your testimony.

Mr. **Fuqua**. I might point out about conservation that about 3 or 4 years ago I tried to determine if we could turn the air conditioning and heating off in this room and other hearing rooms on weekends and nights and other times. I found that the building was constructed in a manner that makes it totally impossible to do that. So it's very comfortable in here 24 hours a day, holiday, weekend, or whenever it is. The Federal Government is probably the greatest abuser of energy and the worst offender of energy conservation.

Mr. Lewis?

Mr. **Lewis**. Thank you, Mr. Chairman. First of all let me say it's a pleasure to see Ms. Tschinkel here. I served on the committee that approved her appointment as Secretary of DER. You know, most of us from Florida and the Gators and things like that are always questionable of someone that comes from the University of California at Berkeley, but Ms. Tschinkel certainly has belayed those fears.

Having the opportunity to share the podium with her on a program in West Palm Beach last year was a highlight in my life. She is, certainly, a breath of fresh air. DER people most times are frowned upon or looked upon with disdain, but Vicki has made the private sector work with DER and vice versa, and has certainly been fresh air in that area. So, welcome to Washington, Madam Secretary.

I just have one question and I apologize for being late. Being a new Congressman I find that I don't have enough time to get everything done. I don't know if you read your report or just summarized it, but in the solar area which we're very concerned about in Florida, I just did go through a couple of the items that you highlighted in your presentation.

What do you actually feel should be the Federal Government's role as far as research and development in the solar area?

Ms. TSCHINKEL. I think that we found that that needs to be, with a couple of exceptions, very technology specific. That you need to take a pragmatic approach and look at the development of the particular thing, whether it's the wind program, as it's developed over time, or the solar thermal program, and see what are the kinds of things, what, as a practical matter, private industry is doing, what they can do, in addition, and then what's left over to really make it work. However, on a more generic basis, there is a very critical need for materials research of all kinds related to the solar program, more basic research. There is a lot of need for research in biomass production and research in photochemistry.

Mr. LEWIS. I notice, also, in your report that you were talking about continuing the parabolic dish program. Do you feel that from the Federal end we're supplying sufficient funding for the R&D in that area?

Ms. TSCHINKEL. Mr. Lewis, I understand that it's, at least the way the current recommended budget is, not in the budget as we recommended it in our report.

Mr. LEWIS. Do you think overall that solar is a highly promising energy device? We continue to listen to the people that years ago would take a black garden hose outside and wind it up and let the Sun warm up the water and that would be fine for a shower, but we're talking about more advanced development and more highly technical areas, such as solar furnaces, the parabolic dish and the troughs and things like that. Do you feel that the current budget that we have proposed by the Department of Energy is sufficient in this area?

Ms. TSCHINKEL. It's certainly below what we recommended as being possible to put forward a steady regular progress in the solar program area.

Mr. LEWIS. Thank you, Mr. Chairman. I would like to submit other questions for response in writing, if I may.

Mr. FUQUA. Thank you very much.

Mr. Sensenbrenner?

Mr. SENSENBRENNER. No questions, Mr. Chairman.

Mr. FUQUA. Mr. Lowery?

Mr. LOWERY. No questions.

Mr. FUQUA. Thank you very much, Al, for being here, Mr. Thompson, Dr. Bennett, Vicki we're always glad to have you. Thank you all very much for being here and for the fine work that your committees did. I think it's very good to have a outside view to help make some of the very important decisions that we have to make and set the priorities that must be set. I thank you very much for the contribution that all of you have made.

Our next panel of witnesses will be Dr. David Morrison, president of the Illinois Institute of Technology Research Institute and Dr. Richard Rowberg, energy program manager for the Office of Technology Assessment. I understand he will be accompanied by Dr. James Ryan, also of OTA.

Dr. Morrison, we will begin with you.

If you have a prepared statement, which I know you do, you may make it part of the record and summarize it.

STATEMENT OF DR. DAVID L. MORRISON, PRESIDENT, ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH, CHICAGO, ILL.

Dr. MORRISON. Yes, Mr. Chairman, I would like to make my written testimony a part of the record.

Mr. FUQUA. Without objection we will do that.

Dr. MORRISON. I'll try to summarize and probably both elaborate on some of the points that are in that testimony.

I'm David Morrison, president of the IIT Research Institute in Chicago. It's indeed my pleasure to be here this morning to discuss the Federal energy R&D budget, and particularly, industrial energy conservation.

I feel that this is a very timely hearing for the United States, and for that matter, all the nations, since we are in another period of transition in our energy economy. This transition should remind us again of the frequency at which adjustments in energy supply and demand relationships occur, of the uncertainty and instability in our sources of energy, and of the need to take a long range view of energy R&D. We have not solved our long-term domestic energy supply problem. It is only less apparent due to the recession and the abundant world petroleum supply at the present time. The long range view, however, is not being taken. During the past year we have seen the demise of synthetic fuels programs in the United States due to an abundance of oil, failing prices, declining profits in the oil industry, and a cutback in Federal funding for the development of alternative fuels.

Similarly, the spending by DOE on industrial energy conservation programs has been reduced substantially over the past couple of years, and Federal efforts to develop energy conserving technologies have been limited. While the current transition is toward abundant energy supplies and lower costs, by the end of the decade a reversal of this trend is likely with resultant increases in demand and cost. It is well known that the technological innovation cycle is long, on the order of 20 years from the initial concept to the first commercial realization. Thus, we must take a long range view in energy technology if we are to be prepared for our future energy needs.

One of the underlying issues confronting us is the role of the Federal Government in energy technology programs. In the time of an energy crisis such as the oil embargo of 1973–74, the energy problem assumes a level of national significance similar to defense, and targeted programs on the development of alternative energy resources, and on energy conservation techniques and their utilization are appropriate. If there is not a crisis, energy can be treated as any other national resource and Federal energy technology programs must be directed at the prudent development and management of these energy resources. Under the noncrisis conditions, the primary role of the Federal Government is to expand our technology base in areas that will increase our knowledge of phenomena and processes relative to commercial and industrial applications. This technology base must be maintained to meet the transitions of the future. As a part of this role, the Federal Government should take the leadership to show the technical feasibility of new processes and how emerging energy technologies can be used to achieve our national objectives.

Our second role for the Federal Government is to perform high risk R&D which is beyond the capability of a single company or industry to support. Yet, if this R&D were successful, it could have a significant impact on commercial practice. The risk may be that the time to commercialization is too long to yield a reasonable return to a company in today's business environment, the technology may be too basic for an industry to see its commercial potential, or the magnitude of the costs of a critical field trial, pilot plant, or demonstration may be too great.

The third role for the Government is to provide educational and training opportunities that will enhance and expand the human element of our technical resource base. The goal is to develop a national technological capability that is institutionally dispersed throughout the country, that is readily accessible to industry and meets the evolutionary business needs, and that can participate in a coordinated effort with the Federal Government in industry to respond to national crises. The importance of a strong and dynamic capability to our national well-being cannot be overemphasized.

A fourth role of the Federal Government is to increase the awareness and utilization by industry of Government developed technologies through an active transfer program. If properly conducted, the technology transfer program would not only improve our industrial base through the infusion of technology but would also bring the need for technological developments to the attention of the Federal Government.

I would now like to address the activities of the National Research Council with regard to industrial energy conservation. In June of 1980, the National Research Council was asked by the U.S. Department of Energy to evaluate the industrial energy conservation program. A Committee on the Assessment of the Industrial Energy Conservation Program was formed under the aegis of the National Materials Advisory Board, specifically to:

Review the role of the Federal Government in research, development, and demonstration in industrial energy conservation, to determine if the plan were appropriate to that role;

Second, to critically examine DOE's industrial energy conservation plan to ascertain its potential effectiveness;

Third, to identify gaps and omissions in the plan; and

Fourth, to determine if the plans of this Federal program on industrial energy conservation are appropriate, and assess the likelihood that the plan would achieve those goals.

The Department of Energy's Office of Industrial Programs was designed to have major impacts on industrial options for utilizing selected existing, but inadequately used, technologies; for improving energy efficiency and for investing in energy conservation.

I have had the pleasure of serving as the Chairman of the National Research Council's industrial energy conservation committee since its inception. The committee members, who had a knowledge of energy technologies and policies as well as industrial practices, were drawn from universities, industries, and the not-for-profit independent research institutes. There have been a total of 12 members on the committee over its 2½ years of existence.

The committee's charter was confined to industrial energy conservation excluding the agriculture sector. Likewise, buildings and commercial energy uses were not a part of the committee's responsibility.

Since we were a group structured out of the National Research Council, we addressed only the technological issues associated with industrial energy conservation, which was the strength of the committee members that were chosen to participate, and did not spend appreciable time looking at incentives, nor did we address the budget level.

The committee in its report of approximately a year ago identified nine findings covering the Office of Industrial Programs content and management and developed eight recommendations. These findings are detailed in the report NMAB 395-2 and can be made available to the committee and could be entered as a part of this record.

Today, however, I would like to touch only on the principal finding and one of the recommendations. The principal finding of the committee was that on balance, the Office of Industrial Programs has done a commendable job in implementing the Federal role in industrial energy conservation that was established by Congress. It has spent the moneys appropriated to it in a prudent manner, as evidenced by the results of its efforts to date, and those projects that appear to have future potential.

Since 1972 American industry has made significant improvements in energy use. Many of the more energy-intensive industries began programs during the mid-1970's that established voluntary targets for reducing energy consumption per unit of production. Later legislation required the establishment of energy-efficient improvement targets for 1980 for the 10 most energy-consuming industries. By the end of 1980 each of the 10 industries had met or surpassed its target. In 1981, these 10 industries consumed 12.66 quads of energy. If they had continued to consume energy at their 1972 efficiencies the consumption would have been 15.12 quads so through conservation the 10 industries are now saving about 2.5 quads annually, or more than a million barrels a day of oil equivalent.

The specific accomplishments of the Office of Industrial Programs that have contributed in part to these energy savings were presented to this subcommittee by the Department of Energy in a January 1983 briefing. These accomplishments are examples of the well-balanced mix of projects that our committee found the Office to be funding. We observed that most of the Office of Industrial Programs projects are directed at stimulating the implementation of existing but underutilized technologies or at developing new technologies which involve greater risk than industry normally assume. Both types of projects are appropriate for Federal funding.

The principal recommendation of our committee is that the activity of the Office of Industrial Programs should emphasize the support of long-range, high-risk R&D, whose results would contribute to the basic technology of a particular industrial area.

The improvements to date in energy use by industry have been accomplished mainly through closer attention to operating procedures and through simple equipment modification. Significant additional conservation of energy will be achieved only through the development and application of new products, processes and process control techniques, and waste heat recovery technologies. These technologies tend to be generic for any given industry. Generally they require many years to develop, are expensive to implement, and are not currently being pursued by industry. To meet the national need for effective energy utilization, the Federal Government can assist industry through the development of technology and the provision of incentives for its utilization. The Office of Industrial Programs can serve as the focal point and manager of these activities.

During this past year, the committee has examined the Federal role in industrial energy conservation from the perspective of two industries, the pulp and paper industry and the general manufacturing industry. The findings of this study have not yet been released but the committee did identify additional high risk R&D projects that could lead to energy conserving technologies in both of these industries.

I expect this report should be released by the National Research Council within the next few months and it can be made, at that time, available to the committee.

Just again to highlight that, in the pulp and paper industry, the committee found that the development of more efficient technology for the recovery furnace, improved thermal efficiency of paper drying, and increased utilization of forest residuals and other wood fuels would lead to better energy utilization in this industry. Improvements in metal forming techniques, such as cold forging, and advanced metal finishing methods, such as laser heat treatment, could improve energy utilization within the general manufacturing industry. Both of these industries could benefit from increased awareness of the technologies already developed by the Federal Government, including agencies beyond just the Department of Energy, that could conserve energy. A more effective technology transfer program would be useful.

It is my personal opinion that the Department of Energy should continue its industrial energy conservation program with funding at least at the level of the fiscal year 1983 appropriation. This program has made useful accomplishments and does provide national leadership in the development of technology for industrial energy conservation.

I think it is a good investment. In the past decade the Federal Government has spent more than $242 billion on research and development. The amount of funds spent by the Office of Industrial Programs is $170 million, less than a tenth of a percent of the total. Industrial energy consumption in 1981 was less than it would have been if it had continued to consume at the 1972 levels of efficiency by more than the equivalent of a million barrels a day, with the current price of $30 a barrel, a $30 million a day savings soon repays this magnitude of investment.

I'll be very happy to address your questions.

[The prepared statement of Dr. Morrison follows:]

Statement of Dr. David L. Morrison
President, IIT Research Institute
Before
The Subcommittee on Energy Development and Applications
United States House of Representatives
March 9, 1983

I am David Morrison, President of the IIT Research Institute in Chicago. It's a pleasure to be here this morning to discuss the Federal energy R&D budget, and particularly, industrial energy conservation.

This is a timely hearing -- the U.S., and for that matter, all nations, are in another period of transition in our energy economy. Less than 10 years ago, we in the U.S. enjoyed low energy costs and ample energy supplies. In 1973, we consumed 74.6 Quads with 46% of our energy supplied from petroleum. 26% of our oil was imported. At that time, only a decade ago, we would have projected our annual consumption to be as high as 110 Quads in 1983. The OPEC embargo of 1973, the Iranian crisis of 1979, and the recession of the 1980's have dramatically changed this picture. In 1982, we consumed 70.9 Quads and only about 25% of our oil was imported. We have reduced our energy consumption as well as our dependence on foreign oil significantly. The rising cost of energy and the sluggish economy has reduced consumption, and the potential for disruptions in supply coupled with an expanded domestic exploration program in the late 1970's, have led to a reduction in imports.

This transition should again remind us of the frequency at which adjustments in energy supply and demand relationships occur, of the uncertainty and instability in our sources of energy, and of the need to take a long range view of energy R&D. We have not solved our long-term domestic energy supply problem. It is only less apparent due to the recession and the abundant world petroleum supply at the present time. The long range view, however, is not being taken. During the past year we have seen the demise of synthetic fuels programs in the U.S. due to an abundance of oil, failing prices, declining profits in the oil industry, and a cut-back in federal funding for the development of alternative fuels. We are not proceeding on a significant scale to develop technology for commercial production of fuels from our abundant and stable resources of coal and oil shale. Many of the projects that had been started have been terminated, and the funds through DoE's fossil energy program to expand our technical base and pursue advanced concepts have diminished significantly over the past couple of years. Similarly, the spending on DoE's industrial energy conservation program has been reduced substantially over the past couple of years, and federal efforts to develop energy conserving technologies have been limited. While the current transition is toward abundant energy supplies and lower costs, by the end of the decade a reversal of this trend is likely with the resultant increases in demand and cost. It is well known that the technological innovation cycle is long, on the order of 20 years from the initial concept to the first commercial realization. Thus, we must take a long range view in energy technology if we are to be prepared for our future energy needs.

One of the underlying issues confronting us is the role of the federal government in energy technology programs. In the time of crisis such as the oil embargo of 1973-74, the energy problem assumes a level of national significance similar to defense, and targeted programs on the development of alternative energy resources, and on energy conservation techniques and their utilization are appropriate. If there is not a crisis, energy can be treated as any other natural resource and federal energy technology programs need to be directed at the prudent development and management of our energy resources. Under non-crisis conditions, the primary role of the federal government is to expand our technology base in areas which will increase our knowledge of phenomena and processes relevant to commercial, industrial applications. This technology base must be maintained to meet the transitions of the future. As a part of this role, the federal government should take the leadership to show the technical feasibility of new processes and now emerging energy technologies can be used to achieve our national objectives.

A second role for the federal government is to perform high risk R&D which is beyond the capability of a single company or industry to support. Yet, if this R&D were successful, it could have a significant impact on commercial practice. The risk may be that the time to commercialization is too long to yield a reasonable return to a company in today's business environment, the technology may be too basic for an industry to see its commercial potential, or the magnitude of the costs of a critical field trial, pilot plant, or demonstration may be too great.

A third role for the federal government is to provide educational and training opportunities that will enhance and expand the human element of our technical resource base. The goal is to develop a national technological capability that is institutionally dispersed throughout the country, that is readily accessible to industry to meet evolutionary business needs, and that can participate in a coordinated effort with the federal government and industry to respond to national crises. The importance of a strong and dynamic capability to our national well-being cannot be overemphasized.

A fourth role is to increase the awareness and utilization by industry of government developed technologies through an active transfer program. If properly conducted, the technology transfer program would not only improve our industrial base through the infusion of technology but would also bring the need for technological developments to the attention of the federal government.

Before addressing the subject of energy conservation, I would briefly like to comment on the fossil energy program and the development of a synthetic fuels capability within the United States, i.e., alternative energy supply. For more than 30 years we have followed an off-again, on-again pattern in the development of technology for alternative fuels production from coal and shale. At present we are moving into the off-cycle. The technical problems to be solved in the development of a commercial alternative fuels industry are difficult, and a considerable period of time is needed to build an adequate base of technology in this field. I am concerned that the federal efforts are being reduced to a level that the significant problems, such as materials development for the extremely harsh environments of coal conversion plants, are not being addressed, and that efforts on advanced in-situ technologies for production of oil from shale are being eliminated from consideration. These are but two examples of where long-term efforts are needed to build a base of technology. If R&D on problems such as these is not funded on a continuing basis by the federal government, there will be a technology gap when a synfuels capability is demanded. I encourage the subcommittee to examine more fully these longer range issues.

Now let's address the subject of energy conservation. In June 1980, the National Research Council (NRC) was asked by the U.S. Department of Energy to evaluate the Industrial Energy Conservation Program. A Committee on Assessment of the Industrial Energy Conservation Program was formed under the aegis of the National Materials Advisory Board, specifically to:

1. Review the role of the federal government in RD&D in industrial energy conservation to determine if the plan is appropriate to that role
2. Critically examine DoE's industrial energy conservation plan to ascertain its potential effectiveness
3. Identify gaps and omissions in the plan
4. Determine if the goals of this federal program on industrial energy conservation are appropriate, and assess the likelihood that the plan will achieve those goals.

The DoE's Office of Industrial Programs (OIP) program was designed to have major impacts on industrial options for utilizing selected existing, but inadequately used, technologies; for improving energy efficiency; and for investing in energy conservation.

I have had the pleasure of serving as chairman of the NRC's industrial energy conservation committee since its inception. Committee members, who had a knowledge of energy technologies and policies as well as industrial practices, were drawn from universities, industries, and the not-for-profit independent research institutes. There have been a total of twelve members on the committee over its two and one-half years of existence.

I believe it will be useful for the House Energy Subcommittee, as part of its decision making process on the energy R&D budget, to consider some of the recommendations that the NRC committee has made. The principal finding of the committee was that "on balance, the Office of Industrial Programs has done a commendable job in implementing the federal role in industrial energy conservation that was established by Congress and that it has spent the monies appropriated to it in a prudent manner, as evidenced by the results of its efforts to date and those projects that appear to have future potential."

Since 1972, American industry has made significant improvements in energy use. Many of the more energy-intensive industries began programs during the mid-1970's that established voluntarily targets for reducing energy consumption per unit of production. Later legislation required the establishment of energy-efficient improvement targets for 1980 for the 10 most energy-consuming industries. By the end of 1980 each of the ten industries had met or surpassed its target. In 1981, these ten industries consumed 12.66 Quads. Their energy consumption at 1972 efficiencies would have been 15.12 Quads so through conservation the ten industries are now saving about 2.5 Quads annually.

The specific accomplishments of the Office of Industrial Programs that have contributed in part to these energy savings were presented to this subcommittee by DoE in a January 1983 briefing. These accomplishments are examples of the well balanced mix of projects that our committee found OIP to be funding.* We observed that most of OIP's projects are directed at stimulating the implementation of existing but underutilized technologies or at developing new technologies which involve greater risk than industry will normally assume. Both types of projects are appropriate for federal funding.

The principal recommendation of the NRC committee is that:

> "The activity of the Office of Industrial Programs should focus more on the support of long-range, high-risk R&D, whose results would contribute to the basic technology of a particular industrial area."

The improvements to date in energy use by industry have been accomplished mainly through closer attention to operating procedures and through simple equipment modification. Significant additional conservation of energy will be achieved only through the development and application of new products, processes and process-control techniques, and waste-heat recovery technologies. These technologies tend to be generic for any given industry. Generally they require many years to develop, are expensive to implement, and are not currently being pursued by industry. To meet the national need for effective energy utilization. the federal government can assist industry through the development of technology and the provision of incentives for its utilization. The Office of Industrial Programs can serve as the focal point and manager of these activities.

During this past year, the NRC committee examined the federal role in industrial energy conservation from the perspective of two industries, pulp and paper and general manufacturing. The findings of this study have not yet been released but the committee did identify additional high risk R&D projects that could lead to energy conserving technologies in both of the industries. For example, in the pulp and paper industry development of more efficient technology for the recovery furnace, improved thermal efficiency of paper drying, and increased utilization of forest residuals and other wood fuels would lead to better energy utilization. Improvements in metal forming techniques, such as cold forging, and advanced metal finishing methods, such as laser heat treatment, could improve energy utilization within the general manufacturing industry. Both of these industries could benefit from increased awareness of technologies already developed by the federal government, not just DoE, that could conserve energy. A more effective technology transfer program would be useful.

---

*see Attachment for DoE Accomplishments

It is my personal view that DoE should continue its industrial energy conservation program with funding at least at the level of the FY 83 appropriation ($27.9 million). The program has made useful accomplishments and does provide national leadership in the development of technology for industrial energy conservation.

OFFICE OF INDUSTRIAL PROGRAMS

ACCOMPLISHMENTS TO DATE

- EXCELLENT MARKET PENETRATION BY FUMES-AS-FUEL IN COIL COATING

  Successful demo in 1978; 25 installations in line - 15% of market; savings to date 4.0 trillion Btu's; demo equipment buy back $216,000, January 8, 1981; total cost to government: $194,000.

- FOAM FINISHING OF TEXTILES NOW INSTALLED IN 72 APPLICATIONS

  Successful demo; 72 installations; savings to date - 3.6 trillion Btu's total Federal cost: $1.1 million.

- PIPE CROSS REACTOR TO BE ON LINE IN 25 PLANTS SOON

  Successful demo; first unit sold in May 1979; 25 units to be on line this year; estimated savings potential: .08 quad/year.

- ADVANCED CERAMIC RECUPERATOR NOW IN 180 INSTALLATIONS

  High temperature effectiveness demonstrated; 180 installations to date (535 units); recovers heat up to 2600°F., estimated potential savings: .25 quad/year.

- FULL SIZE PLANT ON LINE FOR PLASTICS WASTE CONVERSION

  Successful pilot demo; first full sized petrochemical plant on line; estimated future savings: 20 trillion Btu/year; total Federal cost: $920,000.

- ADVANCED METALLIC RECUPERATOR NOW IN 5 APPLICATIONS AND SAVING 80 BILLION BTU'S ANNUALLY

  Successful demo; 85% effectiveness; estimated future savings: .2 quad/year; 40 installations planned

- FIRST U. S. LOW SPEED DIESEL COGENERATION SYSTEM SUCCESSFUL AND ON-LINE

  Now saving 1.5 trillion Btu's annually...pharmaceutical plant in New Jersey.

- MAJOR PROGRAM FOR ALUMINUM PROCESSING IMPROVEMENT UNDERWAY

  Coal-fired aluminum remelt; wettable cathode development; inert anode development; direct reduction of aluminum.

- THIRTY HIGH EFFICIENCY SLOT FORGE FURNACE TECHNOLOGY INSTALLATIONS

  40% more efficient than conventional units; first unit tested in June 1978; 27 now in operation; estimated annual savings 500 billion Btu's; total Federal cost $2.4 million; no further Federal involvement.

- TWO AFTER BURNER-FREE CUPOLAS ON LINE...MORE PLANNED

  Air injection eliminates need for incinerator; total potential annual savings: 10 trillion Btu's; total Federal costs: $935,000.

- SPACE AGE TECHNOLOGY SUCCESSFULLY ADAPTED TO STEEL PROCESSES

  Hot slabs are scanned by heat sensor to identify defects; first successful test in February 1982; potential annual savings - .25 quads, total Federal cost: $4.0 million.

- ADVANCED CARBURIZING PROCESS IS 17% MORE EFFICIENT

  Atmospheric generation step uses methanol and nitrogen instead of natural gas; first successful test in mid-1981; 200 units in operation today saving 1 trillion Btu/year; total federal cost: $370,000.

- ADVANCED CATALYTIC REACTOR SYSTEM SUCCESSFULLY DEMONSTRATED

  MTBE (octane improver) production unit completed, with one year of operating experience; two more units being planned; major chemical companies negotiating for use of system to produce feedstocks for synthetic rubber and polyethylene.

- COMPUTER CONTROL OF CURING OVEN IS HIGHLY SUCCESSFUL

  Automatic control of vapor concentration permits operation with less dilution air; Federal cost: $458,000; estimated annual savings of 20 trillion Btu's for 7% market penetration. Four units in operation and saving 260 billion Btu's annually.

- TEN ALTERNATIVE IRRIGATION SYSTEMS TESTED SUCCESSFULLY

  Federal cost: $1.5 million; cost shared; estimated potential savings: .1 quad annually; includes low pressure application systems, reduced pressure sprinkling and computer scheduling.

MORRISON, David L.
President
IIT Research Institute
Chicago, Illinois

TECHNICAL AREAS

Project, division and executive level management, energy conversion and utilization, R&D planning, industrial productivity, and environmental analyses.

EDUCATION

Carnegie Institute of Technology, M.S. (chemistry) 1960;
Ph.D.(nuclear chemistry) 1961
Grove City College, B.S. (mathematics) 1954
Northwestern University, Executive Development Program (1971)
University of California, Leadership Laboratory (1975)

CURRENTLY

Responsible for management and operation of the IIT Research Institute. Includes executive direction of seven operating divisions, comprised of over 1,500 staff with annual revenues of $58 million from approximately 550 industrial and 250 government R&D contracts. Has primary responsibility to ensure IITRI's continued growth as a leading independent research institute while maintaining IITRI's national and international reputation for the quality of its staff and the objectivity and utility of services rendered to its clients.

PREVIOUS EXPERIENCE

Associate Director, Battelle's Columbus Laboratories from 1975 to 1977; responsible for program development, especially major interdisciplinary projects.

Senior Program Manager and Manager of Energy and Environmental Programs Office, 1974-1975, Battelle's Columbus Laboratories; responsible for leadership of major energy projects relating to increasing the supplies of energy, conserving energy, and developing new methods for energy conversion.

Manager, Environmental Systems and Processes Department - 1970-1974, Battelle's Columbus Laboratories; annual volume $6 million and research staff of 175 - responsible for environmental characterization, control process development, ecology, and environmental impact assessment.

Chief, Chemical Physics Division - 1967-1970, Battelle's Columbus Laboratories; responsible for mathematical modeling, reactor safety, trace element analysis, and bioenvironmental studies.

Mr. FUQUA. Dr. Rowberg. We would be pleased to hear from you next.

STATEMENT OF DR. RICHARD ROWBERG, ENERGY PROGRAM MANAGER, OFFICE OF TECHNOLOGY ASSESSMENT

Dr. ROWBERG. Thank you, Mr. Chairman.

Thank you for the opportunity to testify today on this issue. The purpose of the testimony which I will summarize is to discuss findings of our recent work about how industry uses energy and what can be expected in the way of increased energy efficiency and some opportunities that may arise for R&D.

Currently, industry uses over 39 percent of all energy used domestically. Between 1973 and 1981, however, industrial energy use has remained virtually constant while industrial output has increased by over 16 percent. This increased energy efficiency, largely in response to higher energy prices, has been substantial and is responsible for the major share of total domestic energy savings over that period.

In spite of the impressive record of energy conservation achieved by industry to date, there is a significant room for improvement. For the remainder of the century we project that U.S. industrial production can grow significantly faster than the requirements for the energy needed for that production. This increase in energy efficiency would result principally from investment in new process technology whose primary goals are to improve overall productivity and/or adapt to changing market demands for products. Because the price of energy is an important concern, however, these investments do not ignore energy. Indeed, such investments can generally be quite effective in bringing about greater energy efficiencies because doing so can be very cost effective. Many of these investments yield returns in terms of energy cost reductions that are very attractive by any ordinary investment criteria.

Our findings show that the most effective means of increasing energy efficiency for the near term, is to create an environment where general investment in industry can take place. As new capital equipment is purchased and installed, it is likely to be more efficient and more productive than that which it adds to or replaces.

I'd like now to discuss some technological opportunities. In the near to midterm, most technologies which can affect energy use in American industry are known, and many will be placed in service over the next 10 years. As an example, in the paper industry there is a trend toward more energy self-sufficiency in integrated papermills, with continued emphasis on cogeneration, sophisticated process controllers and continuous digesters for pulp production. In one case, a $7 million lime kiln which replaced an existing but aging facility, with the added emphasis on energy efficiency produced $2 million in energy savings in the first year, as well as improved environmental containment of noxious vapors. There are numerous other examples some of which are described in the written testimony.

There is a wealth of existing or nearly developed technology that can be installed in the next 5 to 10 years to substantially increase energy efficiency in industry. Although continued research is important in some of these areas, we find that a government role in R&D directed at this near term time period is likely to be of only modest value in assisting industry improve its energy efficiency.

In the longer term, however, there are significant R&D efforts which can effectively contribute to improve energy efficiency, the nature of which make a likely role for the Federal Government important. In particular, the contribution of cogeneration to our nation's electric generating capacity can greatly increase if cogeneration systems are developed that produce high electricity to steam ratios and use more abundant, solid fuels. To aid this, basic work on materials, combustion processes, and advanced gasification techniques are needed, all of which may be an appropriate activity for the Federal Government.

In another important area, the basic chemistry and physics of industrial processes, in other words, those that produce finished raw materials and chemicals from raw feedstocks are topics with considerable research and development opportunity where a Federal role could be of significant value. A particular area of promise is the chemistry of catalysis, especially when coal or solid biomass could be used to drive these industrial chemical reactions.

Another example of this kind of opportunity is in the use of electricity. The unique nature of electricity at the point of use opens the possibility that electrification of process heat applications, where possible, may improve energy use efficiency as well as enhance overall productivity. Some of these technologies are microwave and radiofrequency heating, lasers, induction heating, and electron beam curing or coating. These technologies offer more precise control of the production process, it can take less time, less labor, and produce less wasted byproduct.

Their contribution for the next few decades, however, will be small. Many large problems remain. For example, electromagnetic heating processes require electrode design specific to the work being done to achieve maximum efficiency at lowest capital cost. More importantly, electrochemistry, which would open the opportunity for many of these applications to process heat, has not been a subject of extensive research as a way to carry out industrial chemical reactions.

I've discussed in general terms some promising areas of research in industrial energy where Federal involvement could prove of value. While these research areas all involve energy efficiency to varying degrees, the primary focus is increased productivity. Some, such as those that involve electricity, may not save energy, but may result in considerably lower production costs and the substitution of more abundant fuels for oil and natural gas. Others, such as those dealing with direct combustion of fossil fuels, are likely to be more effective in saving energy. They, too, will have as their ultimate goal an increase in productivity.

Research topics most appropriate for the Federal Government support, in pursuit of these goals, are generally more fundamental than work on specific equipment or processes. This kind of basic research is generally not amenable to specifying energy savings. Yet research in these areas such as basic physics and chemistry of industrial processes, on materials, on combustion processes, and advanced engine concepts, can have very high payoffs in the long-term in both greater energy efficiencies, greater productivity, and greater competitiveness. The opportunities for increasing energy efficiency in industry, in both the near- and long-term are great, and it's important to create an investment climate and provide the scientific and technical base to take advantage of these opportunities.

Thank you. This concludes my prepared remarks. I would be happy to address any questions.

[The prepared statement of Dr. Rowberg follows:]

Testimony of Richard Rowberg, Energy Program Manager
Office of Technology Assessment
before
Subcommittee on Energy Development and Applications
House Committee on Science and Technology

March 9, 1983

My name is Richard Rowberg, and I am Energy Program Director for the Office of Technology Assessment. With me is James Ryan, Project Director for our study on Industrial Energy Use. The purpose of my testimony today is to discuss our findings about how industry uses energy, what can be expected in the way of increased energy efficiency, and what opportunities arise for research and development. My testimony is based on our study of Industrial Energy Use, our recently released report, Industrial and Commercial Cogeneration, and work we have underway on electricity use by industry.

Currently, industry uses over 39 percent of all energy used domestically. Between 1951 and 1973, total energy use by the industrial sector grew by 3.1 percent per year. Between 1973 and 1981, however, industrial energy use has virtually remained constant. Over the same period, 1973-1981, industrial output, as measured by the index of industrial production, has increased by 16 percent. Increased energy efficiency by industry over the decade of the 1970s has been substantial and is responsible for the major share of total domestic energy savings over that period.

This strong movement toward increased efficiency, has been largely in response to higher energy prices and increased scarcity of premium fuels. There are many actions on the part of industry that account for this improvement. Our analysis indicates that these actions fall into four categories. The simplest is housekeeping, such as improvements in maintenance and careful attention to the manual optimization of boiler controls. Next is retrofit additions to existing equipment, such as installation of heat exchange equipment in a boiler. These kind of measures tend to be relatively inexpensive, quickly carried out, and usually do not require elaborate technology. Most investments in these two categories have yielded a very high rate of return. Companies that are energy intensive are generally well aware of the opportunities in these categories and are moving to implement those not already in place.

The other two categories are technological changes in the processes used to manufacture goods, and changes in the slate of products produced in response to a changing market demand. These two are usually considerably more expensive to undertake than housekeeping and retrofit, and their implementation takes more time. In addition, they can require extensive technological development. For energy intensive industries, however, these last two categories are considerably more effective in increasing energy efficiency than housekeeping and retrofit.

In spite of the impressive record of energy conservation achieved by industry to date, there is significant room for improvement. For the remainder of the century we project that United States industrial production can grow significantly faster than the requirements for the energy needed for that production. In particular, we have determined that with a GNP growth rate of 2.7 percent per year, a growth rate of industrial energy use of no more than one percent per year is feasible. This increase in energy efficiency would result principally from investments in new process technology whose primary goals are to improve overall productivity and/or adapt to changing market demands for products. Depending on the industry, these investments will be made to increase production of existing products in view of growing demand, change production technologies to reduce costs in order to maintain market share, or manufacture new products to meet a changing market and/or changing composition of raw materials.

These investment decisions are made on the basis of strategic considerations about the corporation's future profitability and not specifically on energy concerns. Such corporate strategic considerations, we believe, have important implications for research and development planning as we will discuss later. We also found that government policies and actions which focus strictly on energy efficiency of industrial production, such as energy investment tax credits, will have little effect on a corporation's decision about investments in new production and process technology. Although important, energy is one of many factors to be considered in the strategic decision process and incentives aimed just at energy are diluted by the other considerations.

Because the price of energy is an important concern, however, investment in new process technologies do not ignore energy. Indeed, such investments can generally be quite effective in bringing about greater energy efficiencies because doing so can be very cost effective. Despite the fact that new process technologies are more complex than the "so-called" housekeeping measures, many yield returns on investments in terms of energy cost reductions that are very attractive by ordinary investment criteria. As an aside it is worth noting that energy price distortion has dampened industry's response to higher energy prices to some degree. This distortion primarily takes the form that marginal cost of electricity and natural gas are often lower than average costs. Removing such distortions will increase the attention paid to energy in corporation's investment decisions.

Our findings show that the most effective means of increasing energy efficiency in American industry, therefore, is to create an environment where general investment in the industry can take place. As new capital equipment is purchased and installed, it is likely to be more efficient and more productive than that which it adds to or replaces. The fact that many investments have not occurred that do have high returns is a result of the poor climate for investment over the past several years. Although the high cost of money is a critical factor in creating this climate, we have also found that the separation between corporate decisionmaking and engineering analysis of new technologies has added to the reluctance to invest in improved process technology. Ultimately the success of any Federal research and development program on energy efficiency will depend on a change in this climate and a greater recognition of the importance of new technologies to overall productivity.

THE CONSEQUENCES FOR RESEARCH AND DEVELOPMENT

I will now turn to a discussion of technological opportunities for increasing energy efficiency. In the near to mid-term, most technologies which can affect energy use in American industry are known, and many will be placed in service over the next 10 years. For example, sophisticated process controllers, devices to capture and use waste heat, and new multi-fuel boilers, all exist now, but have not yet been employed to the maximum extent that is economically justified.

If economic recovery is underway and is sustained, however, considerable investment in existing and developing technologies is likely to occur. In the iron and steel industry, the two major trends to improve energy use are increased use of electric arc furnaces and continuous casting of steel. The former reprocesses large amounts of scrap metal, thereby saving the energy of formulation, while the latter saves the energy necessary to reheat the original ingots.

In the paper industry, the trend is toward more energy self-sufficiency in integrated paper mills (those which make paper from raw wood, rather than from purchased pulp), with continued emphasis on cogeneration, sophisticated process controllers and continuous digesters for pulp production. In one case, a $7 million lime kiln which replaced an existing but aging facility, produced $2 million in energy savings as well as an improved environmental containment of noxious vapors.

The petroleum refining industry will have to make substantial capital investments in order to respond to changes in the demand for various products while demand for all petroleum products is not expected to grow much, if at all. Nonetheless, the refining industry is projected to become more energy efficient as it invests in new technologies to meet these changes in product demand. Such technologies as computerized process controllers, cogeneration and improvements in heat exchange capacity will also improve energy use in refineries.

In the chemicals industry, retrofit technologies such as vapor recompression and increasing heat exchanger capacity, will play a role in reducing energy costs, but new processes will make the largest contributions. For instance, one major chemical company has, in the last few years, developed a catalytic process for making acetic acid at essentially ambient temperature and pressure, and in extremely high purity. This has dramatically affected the market for this product, making older processes using high temperature reactions and vapor distillation less competitive. In another example, a computerized process controller which cost half a million dollars produced a profit savings of $150,000 per year, primarily through reduced energy costs and higher product quality.

There is a wealth of existing or nearly developed technology that can be installed over the next 5 to 10 years to substantially increase energy efficiency in industry. Although continued research is important in some of these areas, we find that a government role in research and development directed at this time period is likely to be of only modest value in assisting industry improve its energy efficiency. In general, the forces that will bring about these efficiency gains will be expanding markets, lower interest rates and a general improvement in the economy.

In the longer term, however, there are significant research and development efforts which can effectively contribute to improved energy efficiency. Further, because of the nature of many of these technologies, there is likely to be an important role for the government in carrying out this research and development. In particular, the contribution of cogeneration to our nation's electric generating capacity can greatly increase if cogeneration systems are developed that produce high electricity to steam ratios and use more abundant, solid fuels. For this to happen, further work is needed on fluidized bed combustion for combustion turbines, direct combustion processes using biomass or coal in combustion turbines and diesels, and gasification systems for coal and biomass. Although the private sector is exploring many of these areas, basic work on materials, combustion processes and advanced gasification techniques appear to be a legitimate government activity. In addition, the basic chemistry and physics of industrial processes, such as material and chemical production, are topics with considerable research and development opportunity where a Federal role could be of significant value. As the cost incentive to convert from oil and natural gas in many of these processes grows, it is important to determine how new fuels and energy forms can most productively drive the chemical reactions needed to form final products from raw materials. In this vein, a particular, area of promise is the chemistry of catalysis, especially when coal or solid biomass fuels are used to drive the reactions.

Another example of this kind of research is electricity. Today four fifths of the electricity used in industry is for electric motors to perform a wide range of useful functions -- primarily machine drive, compression in freezers, refrigerators and air-conditioners, and pumps and fans. Motor drive, however, uses a relatively small portion of all energy used by industry. The largest share by far goes to process heat applications and steam production, primarily by direct combustion of oil, natural gas or coal. Currently very little electricity is used for these two functions because electricity was at a considerable cost disadvantage when most existing process heat equipment was installed. The relative cost situation is much different today, bringing about a re-examination of the possibilities for electricity in process heat. For these applications, the unique nature of electricity at the point of use opens the possibility that electrification, where possible, may improve energy use efficiency as well as enhance overall productivity. There are a wide variety of electrification technologies now being developed or that may be developed that could offer substantial cost advantages to industry in the coming decades. Some of these technologies are microwave and radiofrequency heating, lasers, induction heating, and electron beam curing of coatings. What most of these technologies have in common is that they offer more precise control of a production process than does more conventional heating. The process can take less time, less labor and produce less wasted by-product. For some of these technologies it is also true that less energy is used, including the energy needed to generate the electricity, because the heating effect can be precisely focussed.

The contribution to industrial production by process technologies using electricity will be small, however, for the next few decades. Many large problems remain despite the possible benefits offered by the precise control of electricity. For example, electromagnetic heating processes require electrode design specific to the work being done to achieve maximum efficiency and lowest capital cost. Also, electrochemistry has not been subject to extensive research as a way to carry out industrial chemical reactions. Similar argument can be made for the entire area of photochemistry which offers the potential of more effectively using solar radiation as an energy source for industrial chemical reactions.

Conclusions

I have discussed in general terms some promising areas of research in industrial energy use where a Federal involvement could prove of value. While these research areas all involve energy efficiency to varying degress, their primary focus is increased productivity. Some topics, such as those that involve electricity, may not save energy but may result in considerably lower production costs and the substitution of more abundant fuels for oil and natural gas. Others, such as those topics dealing with direct combustion of fossil fuels, are likely to be more effective in saving energy. They, too, will have as their ultimate goal increase in productivity.

As we also stated, research topics most appropriate for Federal government support in pursuit of these goals are generally more fundamental than work on specific equipment or processes. This kind of work is generally not amenable to specifying energy savings. Yet research in areas such as the basic physics and chemistry of industrial processes, on materials, on combustion processes, and advanced engine concepts, can have very high payoffs in the long-term in both greater energy efficiencies and greater productivity. The opportunities for increasing energy efficiency in both the near and long-term are great, and it is important to create an investment climate and provide the scientific and technical base to take advantage of these opportunities. This concludes my prepared remarks and I will be happy to answer any questions.

Mr. **Fuqua**. Thank you, Dr. Rowberg. You mention in your prepared statement that there's a wealth of existing or nearly developed technology that can be installed over the next 5 to 10 years to substantially increase energy efficiency in industry.

How much of that is nearly developed, and is that development work being dropped at this time under the present budget that's being proposed to us?

Dr. **Rowberg**. I would think that over the next 5- to 10-year period most of those opportunities are not those that have been taken up by the industrial programs in DOE. I don't know exactly whether there is an overlap there, because I haven't looked at the specific DOE program, but I don't think there has been very much of an overlap in that area.

Mr. **Fuqua**. You mean by lack of overlap, industry is not picking it up and DOE is carrying it out?

Dr. **Rowberg**. In the sense that the technologies industry would be introducing over these next 5- to 10-year periods have not been the subject of DOE research. Those programs that may have been dropped by DOE generally did not fit into the category of being developed or nearly developed by industry.

Mr. **Fuqua**. You go on to say that although continued research is important in some of the areas, you find that the Government role in R&D directed at this period is likely to be of only modest value in assisting industry in improving its energy efficiency. Are you saying by that that there should be more efforts in the further development of these technologies?

Dr. **Rowberg**. I think that what we found to the degree we were able to look at this question, is that the research that would go on with these technologies would largely be carried out by the manufacturers of the equipment or by the industries themselves. These involve improvements in the economies of operation for the most part. It didn't involve fundamental changes in the processes or even substantial changes in pieces of equipment that operated the processes.

Mr. **Fuqua**. Dr. Morrison, the administration has proposed several times to terminate the DOE industrial programs on the grounds that the private sector will do the work. Do you concur with this assessment?

Dr. **Morrison**. No; I don't personally concur with that assessment, Mr. Chairman. It seems to me that after reviewing the more than 200 projects that the Office of Industrial Programs has carried out during its 5 or 6 years of existence, that it's been money well spent by the Federal Government and there is still much to do.

It's very hard to generalize but many industries, for example, the pulp and paper industry really don't do much research and development on their own for a variety of reasons.

If there isn't some stimulation by the Federal Government there will never be any additional energy savings by those industries, at least to a significant extent. On the other hand, if you look at industries like the chemical and petroleum industry that do put a large amount of their funds into research and development, energy and conservation results from a number of the process improvements they make. So, there's a spectrum of what industry can and is doing. So I think the Federal Government's program through the Office of Industrial Energy Conservation does provide the gap fillers that aren't being done by industry.

I think of equal importance, and it's somewhat difficult to express it, is the leadership role that the Federal Government can take. The mere fact that you can show that a technology is feasible gives a target for industry to focus on and to work toward getting those kind of improvements. Without that leadership, without that focus, there really isn't a stimulation for them to see what new technology can do for them. That, I think, is another very viable role for the Federal Government.

Mr. **Fuqua**. What level of funding do you think is appropriate for DOE industrial programs?

Dr. **Morrison**. As I recommended in my prepared remarks, I would regard the fiscal year 1983 level as the real bottom level that one should consider. Something more like the fiscal year 1982 level or even back into the fiscal year 1981 is a more realistic one.

I think we get into the situation depending upon the position in the innovation cycle, that some of the things that OIP could do are fairly expensive. Given the present program or even a reduced program you can't fund those areas that would demonstrate the technology on a scale that industry will be able to really see the economics of it and apply it.

Mr. **Fuqua**. In the course of your review you looked at some Japanese industrial conservation programs. What did you learn from that that would be beneficial to us?

Dr. **Morrison**. That was a very interesting trip that four of us made. We felt that, at least through all of the published information, the Japanese were probably head and shoulders above us in energy conservation and that they surely must be using some new energy technologies that weren't being either explored or utilized in the United States. Much to our surprise after visiting about 10 Japanese companies picked by the Ministry of International Trade Committee as their No. 1 examples of what could be done in industrial energy conservation, we didn't find the Japanese using any technologies that were advanced over what were being used in the United States. In fact, looking back to about the 1972 energy consumption levels the Japanese had realized about the same amount of energy conservation or energy saving on an industrial productivity basis, as we had in this country.

We were also surprised that the decisions to use industrial technologies that would improve energy conservation were being made on the same basis in Japan as they were in the United States. That is, no change would be made in the process, or add-on technologies would be implemented, unless there were return on investments in something like a 2- to 3-year period. So, the industrial decisionmaking process in Japan was basically no different than it is here in the United States.

We also found that the Japanese did not seem to be pursuing a very intensive long range industrial energy research and development program. Although they talk about their moonlight project, it was very difficult to get solid details on anything that was being done in that conservation program.

I think the overall summary was that we were pleased to find out that the Japanese were not beating us in this particular area of technology. We were doing just as well as they were.

Mr. **Fuqua**. Dr. Rowberg, you think that the Department of Energy ought to be funding R&D aimed at reducing industrial energy waste or wasted energy?

Dr. **Rowberg**. One area, for example, that we found was low temperature heat which is the vast majority of the energy that is in a sense wasted. On the other hand, it's a low quality energy because of its low temperature. This is a kind of area that is generic; that has no specific applications at the moment but because of the large amounts of energy and the potential for making use of it, it's an area that would be a good opportunity for research on the Federal level. To that extent, there is an opportunity for research there. Funding and how much and in what directions I can't speak to.

Mr. **Fuqua**. Mr. Lewis?

Mr. **Lewis**. Thank you, Mr. Chairman.

Dr. Rowberg, do you believe that the R&D tax credits have been helpful in stimulating the industrial R&D activities?

Dr. **Rowberg**. We looked at the industrial tax credits, but not specifically at the R&D tax credits. We didn't find the energy conservation tax credits to be very helpful in stimulating conservation. I can't really speak to the R&D tax credits.

Mr. **Lewis**. Could anyone on the panel speak to that? Dr. Morrison?

Dr. **Morrison**. It's been my general impression as head of a research institute that does a reasonable amount of R&D for industry, that the industrial tax credits have not been a stimulation, at least in this economy, with regard to increasing industrial expenditures in R&D. They still are spending in those areas where their need is highest and the fact that a credit is there is not a stimulation to do some project that may be of a lower priority.

Mr. **Lewis**. Has the capital investment tax incentives accelerated depreciation helped at all?

Dr. **Morrison**. In the industries that we have dealt with I think it has made a definite step forward for them. Again, it's unfortunately colored by the status of the economy, and with everything being down it's only a marginal improvement.

Mr. **Lewis**. In answer to the chairman's question you indicated that you would like to see the 1981-82 funding level as a low focal point; what do you really think that the Federal Government's responsibility is as far as helping to initiate, motivate and further the R&D in industry?

Dr. **Morrison**. As I covered in my testimony, I believe, there are four roles for the Federal Government and one is this overall leadership position to be able to hold up a technical feasibility target. The second is the generic R&D which benefits a number of industries, yet, no single industry or no single company within an industry is able to make the investment in that particular area. There have been a number of subjects mentioned here today. One that has not been mentioned, for example, the whole subject of tribology which deals with reducing friction which reduces the energy use in a variety of activities, not just simply that of industrial machinery. This is an area that has never received a tremendous amount of funding anywhere, yet it cuts across the board in many areas. This is an example of generic technology.

The third role is where the Federal Government is to see that all of its technology is transferred. One of the things that our committee has found over this last year, in looking at the pulp and paper industry and the general manufacturing industry, that there is a tremendous reservoir of technology sitting on the shelf not being used. The Office of Industrial Programs funded a project to look at six national laboratories, not just in the industrial energy conservation, but in all of the projects they were doing and identified a number of opportunities where the pulp and paper industry could use the technology that was being developed. We tend to look at the manufacturing and technology program within the Defense Department in terms of defense applications, yet there is a tremendous amount of industrial productivity and industrial energy saving that could come out of it.

We've already made the investment. The technology transfer program needs to be emphasized.

Of course, the fourth role is the training of scientists and engineers, as well as the businessmen and the economist to be sensitive to energy; its use, its costs, and how it could be used more wisely. I think the education role is a very important one, as well.

Mr. LEWIS. With the possibility of a reasonable reduction in oil prices, do you think this is going to reduce the incentive of private industry to look for alternatives and also to maintain a high level of conservation?

Dr. MORRISON. Certainly with the reduction in the energy costs the attention that energy conservation is going to get at the board level or top management level is going to decrease. Unfortunately, if we look back over the last decade or two we find that this is a cyclic phenomena. My own view is that within the next 3 to 5 years we are going to be on the upswing again in terms of energy prices. People that are really farlooking should be looking at that up cycle and kind of ignore the downtrend here in terms of energy prices. We should do the necessary research, development and implementation that will prepare for the future.

Mr. LEWIS. Realizing that conservation is our first alternative source, what I'm concerned about is that if we have a lack of initiative with industry and we get ourselves into a position that we're going to start using more fossil fuels, so to speak, is industry really looking realistically at a depletion rate in fossil fuels in the next 15 to 25 years? Or do we have to come up with alternatives and provide additional high-level conservation?

Dr. RYAN. The individual decision whether to implement a particular energy conservation technology or not depends on many factors of which the saving of energy is only one. The case studies that we looked at as part of our industrial energy use report indicated that no company had a specific, set aside, pot of money for energy conservation projects. Almost universally, the companies with whom we talked had some type of plan on which they looked at individual markets for their products that they made; they looked at the impact of Government policy; at the competition they were facing from either technological or foreign sources within a particular industry. All of these factors entered into their decision of whether or not to put in a heat recooperator or vapor recompression device or whether to put a new paper machine in place.

It's our feeling that the greatest changes in energy consumption come about when new equipment is put into place. A new papermaking machine may only consume 25 million Btu's per ton of paper whereas the older machine consumed 35. So you have a great change in energy efficiency when you can put in new technology and new equipment, but the new equipment only gets put in place when the market is ready for it.

Dr. ROWBERG. Our findings indicate that the question about declining or stable oil prices may not be quite so important for these industrial decision. In other words such price behavior may not act negatively in terms of reducing incentives for making these investments. Of much greater importance is the necessity for improvement in the investment climate so that these industries will invest.

Mr. LEWIS. We go into a cyclic effect, and everytime we have a scare, say from OPEC or someone else, we get very energy conscious; we become very conservation conscious; we look for additional synthetic fuels. But when we're in this level plateau, I get concerned that industry really doesn't care so long as it's making a margin of profit. It keeps its energy conservation at a reasonable level so it's more beneficial to the stockholders than it is to the consumer, and I get very concerned about this. Then we have a scare, and again we're back into heavy conservation. I'm a free enterprise person so I'm not knocking industry, but I get very concerned that industry does not continue and set aside sufficient funds in order to look for alternatives, rather than wait to come to the Federal Government and say we need more money when another scare comes.

Dr. MORRISON. It is my opinion that industry is reasonably good at strategic planning and that the forward looking companies have factored this cyclic phenomena into their thinking. Unfortunately, the day-to-day decisionmaking processes probably focus more on the lowest unit cost of production. If an abundant inexpensive energy supply can be found rather than invest in new technology or new equipment, the lowest cost approach is to us more energy and not make the other investment.

It's very difficult to determine, without having a detailed knowledge of what the R&D program is or what the investment strategy is within industry, at just how well prepared they are for any future shocks on the system, either with regard to the loss of energy supply or rising price situations.

Dr. ROWBERG. I think Dr. Morrison stated correctly that on the longer term those things are factored in. It's less of a concern. It's these short-term or day-to-day actions plus the possibilities of severe shocks that cause the problems that you have alluded to.

Mr. LEWIS. I see.

Thank you, I have no further questions.

Mr. FUQUA. Unless there are any further comments the subcommitte is adjourned at further call of the Chair.

[Whereupon, the hearing was adjourned at 11:32 p.m.]

1984 DEPARTMENT OF ENERGY AUTHORIZATION

THURSDAY, MARCH 10, 1983

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:31 a.m., in room 2318, Rayburn House Office Building, Hon. Marilyn Lloyd (acting chairman of the subcommittee) presiding.

Present: Representatives Lloyd, Ottinger, Nelson, Durbin, Sensenbrenner, and Schneider.

Staff present: Martha Krebs, staff director, Eugene Frankel, science consultant, John Ratzel, minority counsel, and Daniel Steinway, minority counsel.

Mrs. Lloyd. The subcommittee is now in session. Today, we will receive testimony from outside witnesses on the DOE conservation R&D programs.

One area we are especially concerned with is building energy research. The subcommittee held a hearing on building energy research last July and received a great deal of very helpful testimony. We then cosponsored a workshop in January with DOE and a number of private sector organizations to formulate a national research agenda in this area.

I am pleased to be able to present the first results of that workshop at today's hearing. A set of summary tables has been prepared for the members to give an overview of the findings of the workshop.

As you can see, the workshop recommended more than 60 research topics divided into 6 broad research areas. For each research topic the workshop evaluated the stage of completion, level of effort required, time required, best way to accomplish the task and the urgency of the activity. A detailed report is being prepared which will discuss the results of the workshop at some length. We expect that report to be available within a month.

We intend to use this summary as a guide in formulating our 1984 budget recommendations. The staff has compared the DOE fiscal year 1984 budget request with the results of the workshop, and found considerable overlap between the two. But there are also significant areas of research recommended by the workshop that are not included in the DOE budget request. We will look closely at this in the weeks to come.

I would like to express my appreciation, as well as the chairman of this committee, for the more than 50 experts who participated in the workshop and drew up this fine set of recommendations.

You can probably figure out that I am sitting in for our full committee chairman. Don Fuqua had to be at another hearing this morning.

We are sort of wearing two and three hats around here these weeks and we are trying to formulate our budgets for our various committees.

Our first panel will be discussing buildings energy research. We have Mr. Thomas Vonier, Mr. Frank Kensill, and Mr. Donald Carter. Gentlemen, you may proceed with your testimony.

[The opening statements of Mr. Sensenbrenner and Mrs. Lloyd follow:]

OPENING STATEMENT OF HON. F. JAMES SENSENBRENNER, JR. (R-WIS.)

Thank you, Mr. Chairman, for this opportunity to extend a welcome to our distinguished panel members.

We look forward to their testimony on the Buildings Energy Research Conservation Programs and the Multi-Sector Conservation Research Programs conducted by the Department of Energy.

The Administration has proposed significant reductions in these programs for Fiscal Year 1984. These reductions are premised upon the Administration's commitment to fund only those research programs that may be termed "long-term, high risk" activities that the private sector is unable to fund. As representatives of corporations and organizations that have been involved in conservation activities, your thoughts concerning the underlying premise of the Administration's proposals and the impact that prior programs have had upon our economy and our energy supply, will be appreciated and useful in determining the appropriate budget level for these programs.

OPENING STATEMENT OF HON. DON FUQUA (D-FLA.)

Today, we will receive testimony from outside witnesses on the DOE conservation R&D programs.

One area we are especially concerned with is "building energy research". The subcommittee held a hearing on building energy research last July and received a great deal of very helpful testimony. We then cosponsored a workshop in January with DOE and a number of private sector organizations to formulate a national research agenda in this area.

I am pleased to be able to present the first results of that workshop at today's hearing. A set of summary tables has been prepared for the members to give an overview of the findings of the workshop.

As you can see, the workshop recommended more than 60 research topics divided into 6 broad research areas. For each research topic the workshop evaluated the stage of completion, level of effort required, time required, best way to accomplish the task and urgency of the activity. A detailed report is being prepared which will discuss the results of the workshop at some length. We expect that report to be available within a month.

We intend to use this summary as a guide in formulating our 1984 budget recommendations. My staff has compared the DOE fiscal year 1984 budget request with the results of the workshop, and found considerable overlap between the two. But there are also significant areas of research recommended by the workshop that are not included in the DOE budget request. We will look closely at this in the weeks to come.

I wish to express my appreciation to the more than 50 experts who participated in the workshop and drew up this fine set of recommendations.

STATEMENT OF THOMAS VONIER, THOMAS VONIER ASSOCIATES, INC.

Mr. Vonier. Members of the committee, my name is Thomas Vonier. I am president of Thomas Vonier Associates, an architectural firm in Washington, D.C. I am here today on behalf of the American Institute of Architects, the professional association representing over 40,000 of this Nation's architects. I am an appointed member of the AIA's national energy committee, on which I serve as chair of a working group concerned with energy-related research needs for the architectural profession. I am also a director of the Washington, D.C. chapter of the AIA, one of the largest chapters in the country.

I have prepared a written statement which I am asking to have entered into the record.

Mrs. Lloyd. All of your complete statements will be made a part of the record. We do have your statements and you may summarize or proceed as you wish.

Mr. Vonier. Thank you.

The AIA has a long-standing commitment to energy-efficient buildings. For over 10 years the AIA has recognized and emphasized the economic and environmental benefits of an energy-efficient built environment.

Before discussing the subject of this morning's hearing, I want to inform you of the status of the AIA's energy in architecture program, an unprecedented professional development program. As of the first of March 1983, over 3,200 design professionals have participated in this program at their own expense, representing a great many design firms in the United States.

The AIA has also published many energy related resources for architects including, most recently, a series of 12 desk-top references covering such subjects as daylighting, building envelopes, solar control, shading, glazing materials, and photovoltaics. I brought with me this morning a copy of the reference concerned with daylighting for your review.

Each of these publications has cost approximately $20,000 to produce. I must also mention that they benefited greatly from the freely available public domain information that has issued from the Department of Energy's research efforts over the past few years.

Earlier this year the AIA, along with other professional associations and the Department of Energy, sponsored a major international conference on the state of the art in daylighting. To date, the AIA has spent over $2 million on these activities, all of which are designed to improve the energy skills of our members, and we believe that these have been extremely worthwhile investments of our members' dues.

I was invited to comment on the DOE budget proposals for research and development in fiscal year 1984 related to buildings. I believe, however, that my remarks ought to begin at a little more fundamental level. I think we need to begin with the premise that energy conservation is in the national interest. It is sound economic policy. It is sound environmental policy. It is sound national security policy. The AIA views energy conservation in the built environment as the single largest and least expensive source of energy for the two decades ahead.

As this administration would apparently have it, this potential will be realized by efforts of the private sector acting in response to market signals. Well, we have met the private sector and it is us. My fellow architects and I could not be more squarely in the private sector. We are well accustomed to working with market signals. Let me begin by saying that we see energy conservation and renewable energy use in buildings and communities as the major energy opportunity for this country. An opportunity that requires strong Federal leadership, and one that is in danger of being lost or needlessly put off.

Market influences alone are not likely to bring about the developments we seek, so we take this budget very seriously. As I comment on the budget I will be drawing on experience that I had at the Building Energy Research Workshop sponsored by the House Committee on Science and Technology earlier this year in Carmel, Calif. The staff for this committee did a great deal of work, hard and useful work, in preparing for the Carmel session, for which my colleagues and I are grateful. The AIA also greatly appreciated the opportunity to cosponsor this session. We believe it was an excellent beginning. It is critical, in our view, that the Department of Energy continue to forge the cooperative relationship with major building industry representatives and we were heartened by the good efforts put forth in Carmel by Deputy Secretary Tribble and his associates. This session was only a beginning, however. As the fiscal year 1984 budget suggests, there is more needed in the way of deliberation, discussion, and direct consultation.

Let me state our concerns over this budget in six categories as follows:

First, it seems to reflect an almost inversion of what we understand to be this administration's attitude about federally supported research. The budget seems to support many things that one might reasonably expect the private sector to undertake, leaving nearly unsupported those things that are clearly not going to be done with private dollars.

It also does not reflect our experience at Carmel and the priorities that came from that meeting.

Second, it reflects total abandonment of the performance approach to encouraging energy efficiency in buildings. By concentrating on individual building components, materials, and pieces of hardware, it ignores the issues of systems integration and whole building performance that are crucial to real results. This point is related to the first: The closer one gets to specific building components and subsystems, the closer one is to the kind of research the proprietary interests are likely to support.

Third, we see nothing reflected in this budget that speaks to the interests of whole communities and collections of buildings. Along with our colleagues in the planning and urban design professions, architects recognize that the very organization and infrastructure of urban environment has a major and direct influence on needs for energy. Yet the community systems aspects of the Department's programs appear to be missing.

Fourth, there is little in this budget that pertains directly to the needs and opportunities associated with energy use in existing buildings. We recognize that a large majority of the buildings that we will have for the next 20 to 30 years are already here today, and many are in need of attention. There are whole areas of research needed here; in 1984 the AIA will sponsor a major technical conference on this subject, and would like to see at least the type of joint effort with DOE that we benefited from in the daylighting conference I described earlier.

Fifth, in terms of overall spending, it appears that the challenges and opportunities warrant levels of support that are at least two to three times above the proposed levels. It appears to us that conservation programs could justify spending in the range of $18 million, while passive solar, as a distinct area, could warrant in the range of $15 million. We believe that the Federal research and development effort in the energy area needs balance; buildings conservation and renewable energy programs should be given far more priority than is apparent in this budget.

Sixth, we are concerned over management of these programs. They have suffered substantially as a result of reductions in force already gone by, and this budget raises the specter of more to come. For fear of the unproductive personnel shuffling and delays that inevitably accompany reorganizations, it is not possible to advocate at this time—as we have in the past and would do under ordinary circumstances—the consolidation of conservation and renewable energy programs under one building energy research program.

Before I elaborate on a few of these points and attempt to respond to any questions you may have, let me share a comparison with you. In the buildings portion of—that is the buildings section of the buildings and community systems—fiscal year 1984 budget—and I believe this is a charitable interpretation—I see $5.1 million of the $6.6 million proposed for use in areas that pertain directly to the interests of architects and their needs. So, in my view, we are talking about part of part of the overall B and CS budget—31 percent to be exact. At $60 a square foot, this translates into one office building of about 85,000 square feet. This is half the size of the AIA's headquarters building here in Washington, or the equivalent of about 70 new single family homes. It would pay for about 4 percent of the new Hart Senate Office Building, if one believes certain accounts of the cost of that building.

This is perhaps a facile comparison, but it does make the point that we are discussing a very small investment here in terms of the potential returns and the pressing needs.

I would like to elaborate on a few of the six points I made earlier.

First, the distinction between research that the public and private sectors might support. The Carmel workshop never really got to the stage of asking who ought to support which programs. We worked more on the question of what needed to be done, leaving virtually untouched the question of how Federal and private dollars might pay the freight. The building community has at least 1.2 million individual business entities. It has been characterized as an army of pygmies. Each building is likely to involve the interests of many parties, no single one of whom can influence entirely how the building ultimately comes out.

The architectural profession's capacity to undertake research of the kind identified as needed in Carmel is limited by several factors, not the least of which is the fact that clients are understandably unwilling to pay the costs of experimentation. Few, if any, architecture firms have the capacity to do the kind of research identified in Carmel. The AIA Foundation, which has a research division, had last year a total budget of $1.6 million for applied research. All of these funds came from public and private contracts and grants and all were designated for the production of specific information products like the handbook I mentioned earlier. Until there is a full recovery from the current recession, it seems unlikely that the profession will see fit to grant unrestricted research funding. And even then, I am skeptical about the ability of the profession to support the necessary work, because its scope spans the interests of so many groups and our clients are not likely to have an interest in supporting the costs.

The budget, with some notable and laudable exceptions, proposes to do work that on the face of it appears to be more suited to the interests and pursuits of individual private product and materials manufacturers; this is particularly the case in those areas designated under the heading of solar heat technologies. It is just such areas as technology transfer, knowledge dissemination, whole building performance, user behavior research, and others, that are not going to result in proprietary materials and products, that are left short in this budget and are more appropriate in my view for Federal support.

I would like to discuss the performance approach point—the second point I made. We understand why the regulatory dimensions of the building energy performance standards have been removed, but we are concerned that the baby will be thrown out with the bath water. There are over 40 States that now have component-based energy standards in place, representing,in my view, a lost opportunity. We need to see the performance research that has gone on for the past few years, bear fruit. We expect that voluntary building energy targets would find great acceptance in the private sector, but only if DOE completes the technical work needed to create these guidelines, drawing on the very tremendous resource it has already established.

Only through the performance approach will the integration of building subsystems take place in a manner that leads to actual energy efficiency in buildings. This course should not be abandoned, and the AIA is prepared to work fully in cooperation in this undertaking.

The third point about community systems and community energy planning is that we are dismayed to see the community energy systems and community energy planning areas absent from this budget. Our concerns and abilities as architects stretch beyond single buildings. We share an appreciation with our planning colleagues for the enormous gains that could be realized by the pursuit of better knowledge for the design and redesign of our cities and towns, and for replacement of their existing infrastructure. This involves the use of knowledge and skill, as well as the development of new products and technologies. We think there should be a strong Federal presence in this area; without it, there is likely to be little progress, for the efforts required are simply beyond the means of any individual municipality.

In concluding, we have noted the lowering of oil prices with mixed feelings, hoping that the result will not be to lull our profession and the country into a false sense of security about the energy future. All long-term signs point to higher costs for all forms of energy, and most commercial buildings have lives of at least 20 and often 35 or 40 years. With the interest in historic preservation and adaptive reuse, we expect that buildings' useful lives will increase.

Investments in building energy conservation and renewable energy resources are a form of insurance for the future, with desirable implications that are likely to extend well beyond energy alone. We do not regard the proposed budget as enough of a commitment. The result of the Carmel workshop, while only a beginning and in need of refinement, point in a direction that we would like to see reinforced in the Department's budget and programs.

I would be pleased this morning to try and answer any questions you may have, and I would like to express again my appreciation for having been given this opportunity to speak with you.

[The prepared statement of Mr. Vonier follows:]

THE
AMERICAN
INSTITUTE
OF
ARCHITECTS

1735 New York Avenue, N.W.
Washington, D.C. 20006
Telephone: (202) 626-7300
Cable Address: AMINARCH
Telex: 710822 1112

TARGETED BUILDINGS ENERGY RESEARCH
A LOW PRIORITY
FOR
THE DEPARTMENT OF ENERGY'S
CONSERVATION AND
RENEWABLE ENERGY PROGRAMS

A STATEMENT BY

THOMAS VONIER, AIA

on behalf of

THE AMERICAN INSTITUTE OF ARCHITECTS

COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

U.S. HOUSE OF REPRESENTATIVES

March 10, 1983

INTRODUCTION

Good afternoon. I am Thomas Vonier, president of Thomas Vonier Associates Inc., an architectural firm in Washington, D.C. I am here today on behalf of The American Institute of Architects, the professional association representing over 40,000 of this nation's architects. I am an appointed member of the AIA's national energy committee, where I chair a working group concerned with energy-related research needs within the architectural profession, and I am a director of the Washington, D.C. chapter of the AIA.

THE AIA'S COMMITMENT TO ENERGY EFFICIENCY

The American Institute of Architects has a long-standing commitment to energy-efficient buildings. Therefore, before I talk about the subject of today's hearing, I would like to update you on the status of the AIA's "Energy in Architecture" program. As of March 1, 1983, over 3200 design professionals had attended these programs, many at their own expense. This attendance figure represents a great many design firms in the United States.

In addition, the AIA published a desk-top reference series of 12 energy monographs covering a wide variety of topics, including daylighting, building envelopes, shading devices, glazing materials and photovoltaic applications for buildings. I have brought a copy of the daylighting monograph. Each one cost approximately $20,000 to produce.

Earlier this year, the AIA, along with other professional associations and the Department of Energy (DOE), sponsored a major conference on daylighting. To date, we have spent over $2 million on these activities, all designed to increase the energy design skills of our members. We believe that these activities have been an extremely worthwhile investment of our members' dues because they benefit the entire architectural profession, not just AIA members.

THE BUILDING ENERGY RESEARCH WORKSHOP

Today, I would like to comment on the Department of Energy's FY 1984 budget for the buildings-related conservation and solar programs. I will also try to compare its contents to the spirit of the Building Energy Research Workshop sponsored by your committee earlier this year in Carmel, California. The AIA, among others, was a cosponsor of this workshop--an opportunity we greatly appreciated. The AIA thought the Carmel Workshop was an excellent beginning for a more cooperative relationship between the major representatives of building industry and DOE. However, the AIA stresses that this workshop is only a beginning. We need to have more interaction and direct consultation with DOE before a balanced buildings-related research and demonstration program can be worked out.

At the workshop, each working group deliberated over the types of research that are still needed to advance the architectural and engineering professions' and homebuilding industry's ability to design and construct more energy-efficient buildings. The working groups' members brought to bear their technical knowledge and their experience with the institutional impediments that retard the greater use of energy-efficient features in buildings. Both the residential and commercial buildings groups concluded that, in spite of the tens of millions of dollars already spent on energy conservation and solar research, there is a distinct need, whether publicly or privately financed, for the following research and development activities:

1. Occupancy and maintenance practice effects on building energy use.
2. Performance targets.
3. Building construction quality control techniques.
4. Development and validation of building energy analysis simulation program.
5. Heating, ventilation, and air-conditioning equipment performance standards.
6. Energy management and retrofit options for existing buildings.
7. Design tools development and validation.
8. Technology transfer and development of a data repository.
9. Solar and photovoltaic applications for larger-scale buildings.

10. Hardware and control systems for larger scale buildings.

One cannot easily generalize about the list of tasks except to say that they require a sustained and stable effort for a number of years. The tasks reflect the building industry's need for programs that emphasize applied research, product and component development, and field testing, rather than a strict emphasis on generic or basic research. Most require a total effort of at least a million dollars and some require several million dollars.

A LIMITED RESEARCH CAPACITY

As you know, the Department of Energy has asserted that the building industry, with its 1.2 million individual entities, will take over many of the federal activities that were formerly coordinated by DOE and supported by millions of dollars. I must tell you that this assumption is inappropriate, especially given the research capacity of the building industry. The architectural profession's capacity to carry out the level of research needed on any of these 10 topics is nonexistent. Because their scope reaches across the myriad of actors in the building industry and requires a level of coordination beyond the scope of any private sector entity.

Unlike other product manufacturers, architects cannot easily apportion their R & D costs over their clients' projects. Right now, many clients are still unwilling to pay extra for energy design services. They certainly cannot be expected to underwrite the development of a design tool. Furthermore, no architectural firm has the type of research capacity needed for the kinds of activities that were supported at Carmel. Most are limited to materials and design research for individual building projects.

Our conversations with the National Association of Homebuilders (NAHB) and other workshop cosponsors indicate that their members are equally limited in their capacity to carry out the kinds of research support at Carmel because that research will not immediately enhance their economic competitiveness.

Furthermore, DOE representatives have asserted that funds of the research components of the building industry trade and professional associations could be redirected to fund activities that DOE would like to eliminate. In our case, this is not possible. First of all, the AIA Foundation's research budget is relatively small, about $1.6 million. Last year, about $1.2 million was devoted to energy activities. All of these funds come from private and public contracts. These funds are designated for specific deliverable projects in the applied research area. Even the funds from the AIA itself are devloted to producing products for the design profession, like the design handbook I showed you earlier. The Institute is unable to give the AIA Foundation unrestricted R & D funds until the building industry fully recovers from the current economic recession.

Even if the AIA Foundation had adequate resources, it would not have the capacity to carry the types of research that were supported at Carmel. The AIA Foundation is best able to collect and analyze data, assemble data bases, implement surveys and package R & D results in formats suitable for AIA members, which is very different from product development or resulting research. I understand that the research components of associations at the American Consulting Engineers Council, NAHB and the Brick Institute are equally limited in their capacity to undertake the kind of research recommended at Carmel.

THE FY 1984 BUDGET

The AIA has analyzed DOE's program activities for FY 1984. We found little that reflects the spirit of the Building Energy Research Workshop in the proposed activities of DOE's FY 1984 programs. We recognize that it was too late for DOE to revise the FY 1984 program activities after the Carmel workshop. However, the AIA would like to comment on what we did find in the proposed budget on buildings-related research.

First of all, it appears that DOE plans to phase out many of the activities that were considered to be the highest priority at the Carmel Workshop. These include performance monitoring, design tool development, indoor air quality research, whole buildings research and most technology transfer activities and performance standards, as well as the passive solar research activities.

Furthermore, the proposed FY 1984 program appears to be making a hodge-podge of research activities. In constrast to Carmel, where the major industry representatives stressed the merits of R & D programs that augmented the building industry's own strengths and weaknesses, DOE's FY 1984 activities appear to be devoid of any coherent policy framework or clear-cut goals.

Of course, the proposed funding levels for FY 1984 are extremely inadequate to even initiate some of the research suggested at Carmel. We believe that the building systems program that is housed in DOE's Office of Building Energy Research and Development should be funded at about 18 million or three times the amount proposed in the FY 1984 budget. We believe that the passive solar program should be reestablished as a separate program and should be funded at about a $15 million level, rather than eliminated.

We are still optimistic about the potential for the department to exhibit a more cooperative spirit, as it appeared to do at the Carmel workshop. However, we are skeptical of DOE's ability to change its course to reflect the workshop's theme of a more balanced R & D program for buildings. But as long as DOE must reflect the Administration's policy of less federal involvement in energy and OMB's emphasis on long-term, high-risk R & D.

DIRECT CONSULTATION

More cooperation is a must. We recognize that the current budget proposed for FY 1984 would prevent DOE from initiating many of these activities proposed at the Carmel workshop. However, nothing prevents the Department of Energy from trying to find more effective uses of the existing research fund it now controls. At the very minimum, we would like to see discussions with individual building industry associations on their members' energy research priorities. As the professional organization for this nation's architects and with almost a decade of energy design experience, the AIA has the capability to assist DOE as it tries to establish its energy-related program for architecturally designed buildings. The AIA has already developed its own energy research agenda. For your information, I have included a copy of the AIA's Energy Related Research Priorities in this testimony. A quick comparison reveals that many of its recommendations are almost identical to recommendations made for commercial buildings research at the committee's workshop.

DOE PROGRAM STRUCTURE

When we testified before the committee last year, we recommended that the active and passive solar programs be combined into a single building energy research program. Since then, the Energy Research Advisory Board, in its report on Solar R & D, has recommended that a Building Energy Research Institute be established. We feel that the time is not appropriate for either of these tasks. After two years, the buildings conservation and passive solar programs have finally regained some stability. We believe that any kind of reoganization would threaten this stability. Our experience indicates that program reorganizations are always distracting and disruptive and frequently cause valuable staff persons to be edged out. None of these programs can afford to lose any more qualified staff people; they lost so many well-qualified staff during the Reduction in Force (RIF) last year. Furthermore, we believe that the building systems and the passive solar programs have overcome their former communication problems. We have seen many joint efforts between these programs during the past year. Consequently, we believe that it is preferable to let these programs remain as single entities and be managed by experienced DOE staff rather than to combine them into a single program.

INSURANCE FOR THE FUTURE

Although oil prices are falling, the AIA believes that the design professions must continue to strive to design more energy-efficient buildings and must not de-emphasize energy efficiency because of a temporary lull. After all, many speculative buildings have a life of 20 to 35 years. All long-term signs point to substantially higher energy prices and, furthermore, abundant energy supplies do not seem to guarantee a drop in price. For example, the nation's supply of natural gas is quite high right now, but the price of natural gas has risen this winter.

Consequently, we believe that we should use the lull to develop an insurance policy for the future. In order to do this, we believe that the gaps in energy design knowledge must be filled. This means figuring out more effective ways to incorporate energy efficiency into new and existing buildings.

The Administration at least in principal appears to agree on this insurance principle. However, as the AIA's representative, I don't believe that DOE's proposed FY 1984 activities will help design professionals further develop their energy design skills. I believe that the course outlined at Carmel would be more likely to create the necessary additions to the design profession's knowledge base. Therefore, the AIA believes that DOE should go back and consider the research priorities established at the Carmel workshop.

SUMMARY

In closing, we are asking you to consider the outcome of the Building Energy Research Workshop when you consider the future funding levels for these programs. We believe that the Carmel workshop's results offer guidance for the Department of Energy's buildings R & D programs, but more discussion with the Department is needed. As we have indicated before, the AIA believes in energy-efficient buildings and does not come to this committee with hat in hand. We have made a commitment to assisting our members to design more energy-efficient buildings. I hope that the Department of Energy can be directed to make the same kind of committment to the building industry.

Mrs. **Lloyd**. Thank you very much, Mr. Vonier, for your excellent testimony.

We are now happy to welcome Mr. Frank Kensill.

You may proceed with your testimony. We do have your complete testimony before us. You may summarize or proceed as you wish. We are happy to have you here.

STATEMENT OF FRANK KENSILL, INSTITUTE FOR HUMAN DEVELOPMENT, PHILADELPHIA, PA.

Mr. **Kensill**. Rather than use the prepared statement I would just like to make a couple of comments on it and then, if I may, just make a summary statement.

The concern that I have is that there is a wonderful opportunity, I believe, in the area of low income energy assistance to generate a substantial number of new employment opportunities—especially at entry level. There is certainly an extremely urgent need.

I have been traveling across the country working in eight States and the situations that I've been seeing indicate that we probably are going to be forced to take a position that everyone has, as if it were a God given right, a right to a certain amount of energy. The decision as to what that amount is going to be, the minimal amount that a person can survive on, is going to make a great deal of difference as far as the entire national budget. I think everyone has an interest in where that floor is placed. If technology is not applied directly to this issue then I think we will be faced with a floor that is high enough to make it very difficult for many of the utilities to survive. I know that in Philadelphia in the middle of the winter over half of all the gas customers are delinquent.

With the rise in prices in many parts of the country people are actually on the edge now of survival. Fuel assistance is a popular program. If need is to be met by subsidy alone, then I think we are caught in a situation where there will be increasing and continual pressures either for the utilities to pass it along to rate payers or for direct subsidy to be given. One way or another, it will become a tax and a burden on everyone.

To work on this problem is going to require intervention. It is not the kind of intervention that can be made by industry. One of the examples would be that we developed a generic approach to conservation in residential heating systems. By generic what I mean is that rather than try to develop a product, what we did was develop a strategy—determine what it was that had to happen. One of the offshoots of this was that we discovered that a great deal of existing hardware could be used in this generic approach. The results that we got were substantially higher than were currently being obtained using the same equipment, by using them in a somewhat different way. This is not patentable. This does not result in any gain to any one company. This is a low income market as well. So that if it is not in a subsidized program the products will not be sold. I think the implications of all this are that while we were able to increase the cost effectiveness of equipment by a factor of two, it would not result in any gain to any one particular company. But it does result in the very substantial gain to the taxpayer or to the rate payer, as it might be.

I think this is the proper role of Federal intervention. If we are committed to keeping people alive, if we are committed to caring for the elderly and the handicapped, then I think we have to be committed to doing it in the most cost effective way. What this means is to back development of the hardware, the systems and the methods for doing this in the most effective way.

If we want to cut the budget I think one of the best ways to do it is to spend some money in learning how to use what we have in the most effective way. This looks like a particularly attractive area. The other thing that is unusually attractive about it is that we found that rather than create high technology jobs that this kind of an approach, although it applies high technology at the entry point, results in a large number of entry level jobs. We would see a potential at this point just in the retrofit program we have been involved in of generating 11,000 new jobs; not jobs that would replace other jobs, but jobs that wouldn't exist if it were not for converting the cost of oil and gas into labor intensive work. The results of this are that the jobs that are created are created by the nature of the program in the very place where the need for employment, and especially entry level employment, is the greatest.

It is a very diffuse kind of effect; typically with the oil companies we've seen, we upgrade the best service man who then is replaced by someone who is driving the truck who is replaced by someone who has been out of work. This is particularly attractive. The important point I want to make is that none of this can happen unless there is support for the developments that make it possible.

Right now we are struggling to put together a gas retrofit program. We know that 30 percent savings for as many as 40 percent of the existing units are possible. We know that, in spite of a great deal of effort, the conventional weatherization approach is not giving very promising results. There are changes that can be made; we are convinced that doubling or tripling the output is indeed possible. If this is done then there will be expansion of employment opportunities, not just in the low income sector, but in all of the sectors. But it takes a coordinated effort and it takes more support than any part of fragmented industry is going to be able to mobilize. Therefore, I feel that it is extremely important that there continues to be the support of both basic research and certainly of the development of conservation measures that can be widely and directly applied to the existing building stock.

Thank you.

[The prepared statement of Mr. Kensill follows:]

TESTIMONY OF FRANK KENSILL

EXECUTIVE DIRECTOR, INSTITUTE FOR HUMAN DEVELOPMENT

Honorable Don Fuqua, Congressmen
The Committee and Staff,
Ladies and Gentlemen,

I would like to thank you for this opportunity to present testimony before the Subcommittee on Energy Development and Applications of the House Committee on Science and Technology.

This is an area of deep personal concern as well as an area of critical need for millions of our citizens. Let me begin with some personal experiences. Three weeks ago my wife visited with an elderly couple as part of a training exercise in Minneapolis. We were trying to determine ways in which we could help persons to deal with the rising price of natural gas. In this household the husband was 78 and his wife 77. They had done everything they knew to reduce the energy losses in their house. They had reduced their thermostat temperature as the gas rates went up. They now had a daytime temperature of 56. They had reduced their food budget and were eating only one meal a day. Their comment given in desperation was that there was nothing else they could give up and stay alive. This does represent, I hope, a still small group in terms of percentage, but that group is increasing rapidly.

In Philadelphia our organization operates an emergency heating service for low-income home owners. We have had two weekends of near zero temperatures when there were approximately twenty-five thousand people that we knew of who were without heat. A high percentage of these were elderly and handicapped, many with limited or no ability to make any alternate arrangements for living. The high incidence of theft that occurs in unoccupied living quarters in many urban areas confront the aged poor with an alternative of staying in a freezing house to guard their belongings or leaving temporarily for public shelter and then having little or nothing left when they return in a few days or weeks.

It is particularly difficult to hear an elderly person describe how they're without heat, one or two of the radiators have already cracked from freezing, the water has stopped flowing in the kitchen, and they are fearful now that the heater itself will freeze. Their house represents not only their last financial asset, but also their tie to happy memories and a purpose in life. In our neighborhood, many cannot speak English and their neighbors and church represent their contact with the outside world. I have repeatedly heard from many of these persons "this is the end of my life". When attempts are made to relocate them, more often than not, this expression of desperation becomes literally true.

There is a very close relationship between these personal hardships and tragedies, the rising prices of energy and the need for technological developments. While energy prices have fluctuated up and down during the past five years, most low-income persons have had to skip any kind of heating system maintenance. As bearings go dry because they have not been oiled, as filters clog because they have not been cleaned, and heaters and chimneys become blocked because they are not serviced, heating systems become less efficient, less reliable, unsafe, and finally break down. The cost of repairs and/or replacements at this point exceed by far the kind of resources that are available, and if temporary repairs are made, frequently the unit is less efficient than before. This further increases the energy costs and makes it even less likely that money will be available to upgrade or replace the equipment.

It is at this point that technology becomes essential. As an example, with the help of Department of Energy monies in the field of oil burning heating systems, we have developed and have demonstrated in over ten thousand homes that a major step to solving the problem of energy consumption, maintenance, and several other related social problems, can be successfully implimented in an administratively simple program with a two year payback. To clarify this point I would like to share the experience of the organization I represent, the Institute for Human Development. If you'll bear with me for two minutes, I believe I can sketch this interaction between Federal development money and direct benefits to some of the most needy of our population, as well as substantial benefits to middle and upper income persons.

At the end of 1978 the Institute for Human Development was developing a weatherization program in Philadelphia. We had had a limited experience in increasing the energy efficiency of oil burning equipment in our buildings as well as those of other non-profit organizations. We wanted to see if the technology could be made relevent to smaller residences. In particular, we wanted to address the problem of retrofitting heating systems within the framework of existing legislation that limited new equipment cost to $100. in each residence. The Bureau of Community Energy in Pennsylvania made an initial grant of $25,000. to explore this possibility in 50 houses. In thirty of these houses we achieved better than 20% fuel reduction with an equipment cost of less than $100. We were given an additional grant to expand the activity to over 500 homes and explore various other options. During the 1980 - 1981 heating season we received a grant from Region 3 of the Department of Energy for a pilot project retrofitting 200 homes using a public-private sector linkage in a program that could be replecated easily in other parts of the country. The savings in that study were better than 20% using existing fuel oil dealers. This program has now been expanded to eight states and the initial data indicates that savings averaging as high as 26.1% are indeed possible.* Significantly, there is strong evidence that the techniques that were developed by I.H.D. first within its own group, then in the Philadelphia pilot, and now in the national program, have resulted in thousands of additional retrofits that have been sold by fuel oil dealers to their more affluent customers.

These savings represent a significant technological development. When Brookhaven National Laboratories contracted with fuel oil dealers to install essentially the same equipment that we are using, their field study showed savings of 12%. When they added field monitoring of the dealers, the savings increased near 17%. When we train the dealers, give technical assistance, and closely monitor the installations, the results are clustered closely in the 25% range. The total cost for this retrofit, if combined with two other options we have developed, savings range between 40 and 60% at a cost equal to the present average expenditure for weatherization. The figures we have projected here very closely parrallel a study conducted by the Commerce Department's National Bureau of Standards, where the savings for conventional weather-proofing are 17% and the weather-proofing plus heating retrofit 41%.

The government's funding was crucial. The heating equipment manufacturers for the replacement market are small and financially weak. There is not one burner company that could have afforded to undertake the kind of research that we did. Rather than develop a feature that could have been patented, we did quite the reverse. We described the characteristics necessary for a radical improvement in heating system efficiency. This generic approach makes it possible to use a wide variety of burners and achieve almost identical results. An extreme example is that as a training exercise, we retrofited existing oil burners for $15. in parts and matched the performance of the best completely new burners available. It is not unusual to retrofit an existing oil-fired heating system to equal or exceed the highest D.O.E. efficiency rating for new commercially available oil-fired heating systems.

---

* For 1,450 retrofits in Minnesota's pilot program.

This enables families who are currently on fuel assistance to reduce their fuel bills between 25 and 60% within the framework of existing funding. It is in the public interest, but is not something that any one company in a highly competitive industry could develop because there are no corresponding benefits to itself. It has benefitted the manufacturers of heating equipment as a group. This is an excellent example of how government research and development can serve as a catalyist to promote the expansion of private competitive industry.

Thus far we have mentioned primarily the retrofit option for oil heated homes. This was when Federal funds stopped. With very limited resources our initial exploration indicates three other areas in which large savings are possible. The existing stock of gas-fired heaters is unfortunately less efficient than oil units of comparable cost and age. Even units that were recently installed to convert from oil to gas are frequently less efficient than the oil units they replaced, according to published D.O.E. figures. Replacing these units with new high efficiency gas units may turn out in some cases to be possible and cost effective with public monies, but for the majority of the low-income gas users the funds are simply not going to be available in the foreseeable future. We have successfully retrofitted a number of older gas units and the indications are that savings in the 30% range are indeed possible with a two year payback.

We have developed low cost methods of partial space heating that are environmentally safe, flexible in application, readily accepted by the users, and expand local industry. The payback appears to be less than two years and they fit in existing programs. We have pilot programs in operation in St. Paul and Minneapolis, Minnesota; central and suburban Philadelphia, and anticipate having over 1,000 installations tested next season. A fourth retrofit involves a method of substantially increasing the benefits of conventional weatherization activities dealing with the shell of the building. A recent study of "Weatherization" in Minnesota showed savings of 14.4% for an expenditure of $1200. The National Bureau of Standards showed savings of 17% for an expenditure of $1336. Studies of infiltration reduction in two western projects showed no significant reduction in energy use. We have some indication that a better than 25% saving can be obtained at approximately $600. by a new method. As of this time we have only a mathematical model, coupled with the field experience of having worked on the shell of over 2,000 low-income residential buildings.

All of the above examples have been very specific and based on our experience. From this limited base we would like to make some observations on the characteristics of technological development where Federal funding seems to be clearly in the public interest and where alternative funding is unlikely to be

Development must take place in the setting in which it will be applied. Much of the less effective publicly supported (as well as private) technological development failed to successfully deal with these "non-technical" matters and so resulted in partially false conclusions and programs.

In recent months there has been an increasing awareness that in every field this country must become more competitive. I am sure that it's true, but the secret of a group becoming more competitive is not in each individual learning how to compete with others, as much as in having persons learn how to effectively cooperate. One of the roles that I believe the Federal government should play is to be a cooperative developer with industry. In some ways it is like two painters looking at a forty foot ladder and arguing over who should pick up the ladder and carry it. The reality is that unless both painters pick up an end of the ladder and both proceed in the same direction, the ladder will not be carried at all. At one end of the ladder are some product specific innovations that attract a particular consumer group and are the appropriate development task of individual private initiative. At the other end are some broad generic developments needed to support the wise expenditure of public funds. This is clearly the governments' end. If they can learn to keep in step with each other we'll get some place.

Let me close by telling a story about two Mid-western women. The older is in her 80's and partially paralyzed by a stroke. She is limited to her bed and a wheelchair. Her daughter has had to give up her employment to take care of her mother. A dozen or so years ago they left the family farm to move into the city. Medical bills have exhausted their savings, and they are approaching desperation with deliquent fuel bills. Fortunately, it is a house in which savings near 60% seem possible. For almost an hour the older cried because she feels that they can no longer take care of themselves, that now they will have to accept public charity and for her "this is the end of my life". As we explained to her daughter about fuel assistance money and how different people have contributed the development of conservation she hit on a way to explain it to her mother. She put it this way, "Mother, you know when we were on the farm and when a neighbor had a problem how we all used to go and help? You know we often helped. Well, mother, this is just like neighbors helping each other, except that now our neighbors are all over this country."

When I take my turn answering the emergency heating phone on a bitter cold winter evening and listen to someone asking for help, I feel I have to respond, -- they're my neighbors. I know that there are technical solutions to at least this part of the world's miseries. I hope we can create in this country that sense of cooperation so that people feel wherever they live they have "neighbors" in Washington who are willing to help.

* * * * * * * * *

I wish I had had the time and staff to attach appendixes and extensive documentation to these remarks. I think this would multiply the value of many of our efforts, and if nothing else, save others from repeating our mistakes. Unfortunately, at present we have neither time nor money.

March 10, 1983

RESUME

Frank V. Kensill
718 W. Norris Street
Philadelphia, Pa. 19122
(215) 769-6771

EDUCATION:

Bachelor of Arts, (Physics with a minor in Electrical Engineering) Swarthmore , 1951.

Master of Divinity, Temple University, Graduate School of Religion, 1954.

Six years part-time graduate level studies in Urban Sociology and Psychiatry, Temple University.

City of Philadelphia Licenses: Electrical Contracting; Heating, Air Conditioning and Oil Burning Equipment (installation and service).

Completion of numerous short courses in Electrical Construction, Codes, Inspections.

Member of N.F.P.A., I.A.E.I., and industry representative on Arson, Natl. Assoc. of Insurance Commissioners.

Recipient with I.H.D. of 1982 highest award in conservation from National Energy Resources Organization.

WORK EXPERIENCE (Outside the church*)

1947	Bartol Foundation of the Franklin Institute (Instrumentation for High Altitude Survey of Cosmic Radiation; conducted expedition to North Pole).
1953-58	Director, Buildings and Development, Phila. College of Art. (Responsible for supervision of Construction and Operation).
1954-58	Associate Professor and Chairman of Science Department, Philadelphia College of Art.
1960	Director, Methodist Mid-Town Parish (Management of Urban Churches and facilities).
1972	Chairman of the Board, Midtown Industries, Inc. (Safety and Security Installations, Heating and Air Conditioning Service Organization), Consumer product safety studies.

1978 Executive Director, Institute for Human Development. Provides training of Energy Conservation Specialists; Research and Development of Combustion Equipment under DOE Grants; Market and Business Analysis; Consultant to Petroleum Dealers Association.

Experience with both theory and practice in electrical and electronic systems, especially control circuits and locating sources of malfunction. Field and laboratory equipment for location and identification of electrical hazards. Knowledge of combustion equipment and controls and reconstruction of accidents resulting from malfunction of safety equipment. Developed training programs for servicemen in fields of heating and air conditioning.

PERSONAL

Age 53, Married, 2 children, Weight 160 lbs. Height 5'9", Excellent health.

*Ordained Elder in E. Penna. Conference of United Methodist Church under special appointment as "Minister to Society" in the areas of energy and employment.

Mrs. **Lloyd**. Thank you very much, Mr. Kensill. That's very interesting. I appreciate your testimony.

Mr. Carter, would you proceed with your testimony?

STATEMENT OF DONALD G. CARTER, CARTER ENGINEERING, INC., SILVER SPRING, MD.

Mr. **Carter**. Thank you, Madam Chairman and members of the committee.

My name is Donald G. Carter. I am president of Carter Engineering in Silver Spring, Md., and am here representing the American Consulting Engineers Council, ACEC.

Accompanying me is Mr. Arnold Windman, president of Syska and Hennessy Engineering, one of the largest firms out of New York City in consulting engineering, and also serving as a national officer of ACEC as their treasurer.

We appreciate very much this opportunity to appear before you today and tell you briefly about the organization that we represent.

ACEC is a national trade association representing over 3,800 design engineering firms employing over 100,000 people. What makes ACEC unique is that membership requires that principals have no financial interest in any product, manufacturer, utility or type of equipment they specify. We have no design-build firms as members so a client may expect complete independent judgment when it comes to any studies, design work or other service we offer.

I, myself, am a professional engineer holding registrations in 10 States and the District of Columbia. I have been running my own firm for over 18 years and have done energy consulting work for the General Accounting Office and the U.S. State Department. I have extensive experience in energy auditing as well as thermal storage, solar, fuel conversion and forensic engineering.

I hope to relay to the members of the subcommittee our impression of what is going on in the private sector in the area of energy conservation and our view of the proper role of the Federal Government.

There is no question that people and businesses are conserving energy and that with the attention focused on the problems, and the benefit derived, they will continue to do so regardless of the course the Government chooses to take. It simply makes economic sense for businesses as well as the small family to save energy. They both know there are certain things that can be done to make the buildings they occupy more energy efficient. They both know also that the technology is available. What is lacking in both cases to move this effort to an even larger scale is the financial capacity and the economic climate to go ahead. So our initial conclusion by those consulting engineers who are designing energy systems is that there is enough energy conservation technology available to save a great deal of energy if we can get the economy healthy enough for these things to begin.

This is not to say there is not more research to be done or that there is no role for the Federal Government to play. There is much about building energy usage we don't know that deserves study; however, it does not need the large sums of Federal money once conceived. In this regard we support the administration's funding level for energy conservation. We also believe there is a proper Federal role in assisting low-income families to weatherize their homes but make no judgment on funding levels.

Our experience with Federal energy programs leads us to make the following comments on them.

The Residential Conservation Service, RCS, and the Commercial and Apartment Conservation Service, CACS, are two programs that have not been fully implemented that we see as unnecessary at this point. Although there is a relatively small amount of Federal money going to them, the regulatory impact snowballs because they require the States to establish a bureaucracy to run them and the utilities a division to implement them. They do nothing more than offer to provide energy audits to those who request them—a service already offered by literally thousands of firms. We believe most utilities themselves do not want to become involved in these programs.

The CACS is of particular concern to us. The irony of this program is that if not for CACS you would have profitmaking businesses, energy firms, dealing with other profitmaking businesses, commercial building operators on an even keel in the American tradition. Each free to pursue and to offer the best deal possible. CACS, as well as other programs, changes this. Public utilities have been interjected into this scenario to offer services already available and subsequently to pass costs on to ratepayers most of whom will never avail themselves of this service.

The RCS which has been partially implemented has not proven itself effective. Some experiences have shown that low- and fixed-income people are less likely to participate in this program and consequently, by having their rates raised, will be subsidizing those who do. These people would be better attended to by the weatherization and low-income energy assistance program than by RCS.

The Potomac Electric Power Co., Pepco, last year reported that free energy advice and loans will cost them $180,000 a year, yet will reduce energy bills by only $15,000 annually. Only those who take advantage of the audit and install energy conservation measures will benefit; consequently Pepco concluded that low-income customers will be disproportionately and inequitably impacted.

The Energy Extension Service, EES, and the State Energy Conservation Program, SECP, are Federal programs that do essentially the same thing: provide information and technical assistance to individuals, small businesses, and local governments. Both programs have at one time or another subsidized energy audits for businesses, a practice of which, as you can gather, we do not approve. Free audits, or taxpayer subsidized audits as we prefer to call them, are fine if you are on the receiving end. However, if you offer that service as a business, as our members do, and lose a potential client to a Government-sponsored program, you tend to become disillusioned. We would ask Congress to scrutinize such programs for these competitive impacts.

Let me give two specific examples. In Connecticut the Energy Extension Service was offering free audits to small businesses. The person running the program declared it an overwhelming success with many businesses taking advantage of the offer. As an aside to his comments he mentioned that the only objections to the program came from a few engineering firms which could have provided that service. To the engineering firms involved, however, it wasn't such a small matter.

A more recent example occurred in North Carolina where the State energy conservation program, which receives money from the Federal Government, was offering free industrial energy audits to manufacturers of food, textiles, and furniture.

Let me quote from a letter received at ACEC:

> I'm fed up with paying taxes to government so that it can compete with me. Industries should pay directly for energy engineering. Why does Congress continue to run up the Federal deficit with schemes like this while consulting engineers are laying off staff and digging into their home equity to avoid bankruptcy from a lack of work?

These are not isolated examples. Surveys of our membership place Government subsidized competition very high on their list of concerns.

Building energy performance standards, BEPS, were originally intended to be in effect a national building code mandatory on all builders. Congress has since modified BEPS to a voluntary standard although some States have implemented mandatory energy standards. BEPS would add $3,000 to $4,000 to the price of a new home, an increment the housing industry, and, more importantly, the American home buyer can ill afford. We believe energy conservation in new and existing buildings should be encouraged through voluntary consensus standards. Specifically, we support the use of ASHRAE, the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Standard 90A-1980.

The world's largest and most comprehensive bibliographic data base on energy is maintained by the Department of Energy's Technical Information Center in Oak Ridge, Tenn. It contains over 600,000 items which are available to the public. The National Technical Information Service adds over 24,000 energy reports to its data base each year. These are available to the public. Energy reports account for over one-third of all the research reports NTIS receives annually. To say much valuable information already exists is an understatement.

Engineers, as the practical users of this information, find some of it useful but also some of it not. Probably even more goes unused or untested for lack of the right people knowing of its existence. We know that the chairman and the subcommittee have been assured that energy R&D money is being wisely spent. However, we would urge that a system be devised to separate out the most useful of research information, possibly by peer review, and use already existing channels, like trade associations and professional and technical societies to disperse practical usable information to those who can put it to the best use.

We would also say that technology transfer is a two-way street and not all important research or discovery is Government sponsored. I think you would be impressed at seeing some of the innovative engineering projects and concepts that are on display annually at our engineering excellence awards. In fact, let me take this opportunity to say you will all be invited to view this year's award winners which will be coming up next month. We urge university and national lab researchers to make a more affirmative effort to become aware of what is being done and going on in the private sector and more importantly what needs to be done. That should be their starting point.

We think Congress in its oversight role would do well to keep closer tabs than it has on the money it chooses to appropriate for research. It should concentrate on supporting technologies that will supply answers to mid- to long-term energy questions. Short-term problems can be handled by the private sector mostly out of necessity. Companies like Carrier and Trane have large research staffs. Smaller firms do research in their normal course of work referring to it as problem solving. I, myself, have spent not an inconsiderable amount of time in developing a plan for energy use labeling of buildings.

I estimate that I have put in at least 200 hours of my own time to devise a system for labeling buildings for energy use. Research has never been an excessive burden to me and I know other consulting engineers spend a lot of their own time contributing to the advancement of the state of the art.

The area of computer modeling of building energy use deserves a hard look. I would guess every Congressman on this panel could find a wide range of computer models in use by energy firms in his district. Some would be private sector developed and some developed by the Government. Of course if you do work with the Government you have to use their program so that increases its use. The Federal Government has sponsored some fine work and provided good information in this area but account should now be taken of the private sector's involvement.

In conclusion, I have tried to present the perspective of the consulting engineer on energy conservation. We see the energy situation in this country much improved from several years ago with energy users having accomplished some remarkable things. We urge Congress to continue to monitor this progress and pursue policies upon which the private sector can rely. With responsible national policies in place, the engineering and other professions can confidently approach efficient, economical, and environmentally safe technologies.

Thank you.

[The prepared statement of Mr. Carter follows:]

Testimony of

DONALD G. CARTER
CARTER ENGINEERING INC.
SILVER SPRING, MARYLAND

representing the

AMERICAN CONSULTING ENGINEERS COUNCIL

to the
U.S. HOUSE OF REPRESENTATIVES
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS,
COMMITTEE ON SCIENCE AND TECHNOLOGY

on the

FEDERAL ENERGY CONSERVATION BUDGET

March 10, 1983

Carter Engineering, Inc. is a private consulting engineering firm specializing in Energy Practice and Forensic Engineering, with experienced full-time personnel in the areas of Plumbing. Heating. Air Conditioning. Lighting and Electrical Power.

Mr. Donald G. Carter, President, is in his eighteenth consecutive year as owner of his firm. During these years he has been able to accept presidencies in such professional organizations as the Consulting Engineer's Council of Metropolitan Washington. American Society of Plumbing Engineers. Washington, D.C. Chapter. The D.C. Council—Engineering and Architectural Societies. as well as active membership in ASHRAE. NSPE. MSPE. Tenn. SPE. NIBS. NFPA and Md. Fire and Rescue Institute. Mr. Carter has been a regular guest lecturer at the University of Tennessee. University of Maryland. Columbia Technical Institute. Prince George's Community College. and others. He has developed and presented seminars to professionals on the subjects of Energy Analyses (Audits). Psychrometry. Absorption Refrigeration. Fan Performance. Centrifugal Refrigeration. Plumbing Systems. Boiler Plant Operation. Systems Selection and Refrigeration. Honors received have come from the Construction Specification Institute. American Arbitration Association, and Consulting Engineer's Council of Metropolitan Washington—"1978-79 Man of the Year."

During the last eighteen years. more than 800 projects have been completed by the firm throughout the United States. South America. Europe. Asia and Africa.

As the ACEC Delegate to numerous hearings for the Government. Mr. Carter has been able to provide testimony on behalf of all consulting engineers. His own *"Scope of Work"* on Energy Analyses has been the theme of his seminars sponsored by ACEC, ASHRAE and private firms in San Francisco, Phoenix. Nashville. New Orleans. Philadelphia. Washington, D.C., Burlington and Concord. His other *"Scope of Work"* for consulting engineers was reprinted and recommended by the Design Professionals Insurance Company.

Thank you Mr. Chairman. My name is Donald G. Carter. I am President of Carter Engineering Inc. in Silver Spring, Maryland and am here representing the American Consulting Engineers Council (ACEC). Accompanying me is Mr. Arnold Windman, the President of Syska and Hennessy Engineering in New York.

We appreciate very much the opportunity to appear before you today. I would like to very briefly tell you about the organization I represent and myself.

The ACEC is a national trade association representing over 3800 design engineering firms employing over 100,000 people. What makes ACEC unique is that membership requires that principals have no financial interest in any product, manufacturer, utility or type of equipment they specify. We have no design-build firms as members so a client may expect complete independent judgment when it comes to any studies, design work or other service we offer.

I, myself, am a professional engineer holding registrations in 10 states and District of Columbia. I have been running my own firm for over 18 years and have done energy consulting work for the General Accounting Office and the U.S. State Department. I have extensive experience in energy auditing as well as thermal storage, solar, fuel conversion and forensic engineering.

I hope to relay to the members of the subcommittee our impression of what is going on in the private sector in the area of energy conservation and our view of the proper role of the federal government.

There is no question that people and businesses are conserving energy and that with the attention focused on the problem and the benefit derived, they will continue to do so regardless of the course the government chooses to take. It simply makes economic sense for businesses as well as the small family to save energy. They both know there are certain things that can be done to make the buildings they occupy more energy efficient. They both know also that the technology is available. What is lacking in both cases to move this effort to an even larger scale is the financial capacity and the economic climate to go ahead. So our initial conclusion by those consulting engineers who are designing energy systems is that there is enough energy conservation technology available to save a great deal of energy if we can get the economy healthy enough for these things to begin.

This is not to say there is not more research to be done or that there is no role for the federal government to play. There is much about building energy usage we don't know that deserves study however it does not need the large sums of federal money once conceived. In this regard we support the Administration's funding level for energy conservation. We also believe there is a proper federal role in assisting low income families to weatherize their homes but make no judgment on funding levels.

Our experience with federal energy programs leads us to make the following comments on them.

THE RESIDENTIAL CONSERVATION SERVICE (RCS) AND THE COMMERCIAL AND APARTMENT CONSERVATION SERVICE (CACS)

These two programs, neither of which have been fully implemented, we see as unnecessary at this point. Although there is a relatively small amount of federal money going to them, the regulatory impact snowballs because they require the states to establish a bureaucracy to run them and the utilities a division to implement them. They do nothing more than offer to provide energy audits to those who request them--a service already offered by literally thousands of firms. We believe most utilities themselves do not want to become involved in these programs.

The CACS is of particular concern to us. The irony of this program is that if not for CACS you would have profit-making businesses (Building Owners) dealing with other profit-making businesses (Energy Firms) in the American tradition. Each free to pursue and to offer the best deal possible. CACS (as well as other programs) changes this. Public utilities have been interjected into this scenario to offer services already available and subsequently to pass costs on to rate-payers most of whom will never avail themselves of the service.

The RCS which has been partially implemented has not proven itself effective. Some experiences have shown that low and fixed income people are less likely to participate in this program and consequently, by having their rates raised, will be subsidizing those who do. These people would be better attended to by the weatherization and low income energy assistance programs than by RCS.

The Potomac Electric Power Company last year reported that "free" energy advice and loans will cost them $180,000 a year yet will reduce energy bills by only $15,000 annually. Only those who take advantage of the audit and install energy conservation measures will benefit, consequently PEPCO concluded that low income customers "will be disproportionately and inequitably impacted."

THE ENERGY EXTENSION SERVICE (EES) AND THE STATE ENERGY CONSERVATION PROGRAM (SECP)

These federal programs do essentially the same thing, provide information and technical assistance to individuals, small businesses and local governments. Both programs have, at one time or another subsidized energy audits for businesses, a practice of which, as you can gather, we do not approve. "Free" audits, or taxpayer subsidized audits as we prefer to call them, are fine if you are on the receiving end. However, if you offer that service as a business, as our members do, and lose a potential client to a government-sponsored program, you tend to become disillusioned. We would ask Congress to scrutinize such programs for these competitive impacts.

Let me give two specific examples. In Connecticut the Energy Extension Service was offering "free" audits to small businesses. The person running the program declared it an overwhelming success with many businesses taking advantage of the offer. As an aside to his comments, he mentioned the only objections to the program came from a few engineering firms which could have provided that service. To the engineering firms involved, however, it wasn't such a small matter.

A more recent example occurred in North Carolina where the state energy conservation program (which receives money from the federal government) was offering "free" industrial energy audits to manufacturers of food, textiles, and furniture. Let me quote from a letter received at ACEC: "I'm fed up with paying taxes to government so that it can compete with me. Industries should pay directly for energy engineering." Why does Congress continue to run up the federal deficit with schemes like this while consulting engineers are laying-off staff and digging into their home equity to avoid bankruptcy from a lack of work?"

These are not isolated examples. Surveys of our membership place government subsidized competition very high on the list of their concerns.

BUILDING ENERGY PERFORMANCE STANDARDS (BEPS)

These were originally intended to be in effect a national building code mandatory on all builders. Congress has since modified BEPS to a voluntary standard although some states have implemented mandatory energy standards. BEPS would have added $3000-4000 to the price of a new home, an increment the housing industry and more importantly the American home buyer can ill-afford. We believe energy conservation in new and existing buildings should be encouraged through voluntary consensus standards. Specifically, we support the use of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Standard 90A-1980.

ENERGY RESEARCH AND DEVELOPMENT

The world's largest and most comprehensive bibliographic data base on energy is maintained by the Department of Energy's Technical Information Center in Oak Ridge, Tennessee. It contains over 600,000 items which are available to the public. The National Technical Information Service adds over 24,000 energy reports to its data base each year. These are available to the public. Energy reports account for over a third of all the research reports NTIS receives annually. To say much valuable information already exists is an understatement.

Engineers, as the practical users of this information, find some of it useful but also some of it not. Probably even more goes unused or untested for lack of the right people knowing of its existence. We know that the Chairman and the subcommittee have been assured that energy R&D money is being wisely spent. However, we would urge that a system be devised to separate out the most useful of research information, possibly by peer review, and use already existing channels, like trade associations and professional and technical societies to disperse practical useable information to those who can put it to best use.

We would also say that technology transfer is a two-way street and not all important research or discovery is government sponsored. I think you would be impressed at seeing some of the innovative engineering projects and concepts that are on display annually at our Engineering

Excellence Awards. In fact let me take this opportunity to say you will all be invited to view this year's award winners which will be coming up next month. We urge university and national lab researchers to make a more affirmative effort to become aware of what is being done and going on in the private sector and more importantly what needs to be done. That should be their starting point.

One of our engineers tells the story that he was giving a presentation on energy to a group and made the statement that he had read over 1000 pages of research reports and found only one page worth anything. Afterward someone from the Department of Energy came over and asked which page was it?

We think Congress in its oversight role would do well to keep closer tabs than it has on the money it chooses to appropriate for research. It should concentrate on supporting technologies that will provide answers to mid to long-term energy questions. Short term problems can be handled by the private sector mostly out of necessity. Companies like Carrier and Trane have large research staffs. Smaller firms do research in their normal course of work referring to it as problem solving. I, myself have spent not an inconsiderable amount of time in developing a plan for energy use labeling of buildings.

I estimate that I have put in at least 200 hours of my own time to devise a system for labeling homes for energy use. Research has never been an excessive burden to me and I know other consulting engineers spend a lot of their own time contributing to the advancement of the state-of-the-art.

The area of computer modeling of building energy use deserves a hard look. I would guess every congressman on this panel could find a wide-range of computer models in use by energy firms in his districts. Some would be private sector developed and some developed by the government. Of course if you do work with the government you have to use their program so that increases its use. The federal government has sponsored some fine work and provided good information in this area but account should now be taken of the private sector's involvement.

In conclusion, I have tried to present the perspective of the consulting engineer on energy conservation. We see the energy situation in this country much improved from several years ago with energy users having accomplished some remarkable things. We urge Congress to continue to monitor this progress and pursue policies upon which the private sector can rely. With responsible national policies in place the engineering and other professions can confidently approach efficient, economical and environmentally safe technologies.

Mrs. Lloyd. Thank you very much, Mr. Carter. All three of you gentlemen have given very excellent testimony.

I'm going to have to go down to another committee meeting and I'm very grateful that Mr. Sensenbrenner has agreed to Chair the hearing. But I would like to ask you and members of the next panel if you would agree to answer questions in writing from Members that were not allowed to be here today because of previous commitments or other subcommittee meetings. We do thank you for being with us today and I thank Mr. Sensenbrenner.

Mr. Sensenbrenner. I have a couple of questions for Mr. Kensill.

In your program, how quickly do you estimate that the cost of the retrofit is recovered in terms of lower fuel costs to the people that you help?

Mr. Kensill. The present figures that we have for the pilot in Minnesota indicate a less-than-2-year payback. Some of the warm room activities have less than one season payback. Most of the things that we are working on would have close to a 2-year payback. That would be typical.

Mr. Sensenbrenner. Have you recruited most of the people you train to do the retrofitting from the unemployed, either directly through job service offices or through programs like CETA or the Job Trainings Partnership Act?

Mr. Kensill. The way in which this has proceeded is that we use the CAP agencies as the administrators of the program, the local program, and then we use in most cases a heating contractor or a fuel oil dealer. We very carefully monitor what happens and normally what does occur is that as the business expands, which it has substantially, the job that is made available in the local company is almost always entry level. That is normally filled by a person who has previously been unemployed. They are not hiring skilled people but are hiring unskilled people.

Mr. Sensenbrenner. Have you had any problems with craft unions, in getting people out of the ranks of the unemployed and putting them into these kinds of jobs, through objections because of apprenticeship programs and the like?

Mr. Kensill. Well, part of this is that we use a kind of ladder approach. The person that is hired is not hired into this program directly, but is hired and could come later into an apprenticeship program. What we basically are doing is creating a job that did not before exist that is filled by someone who is presently employed but who then leaves an opening for someone to move into.

Mr. Sensenbrenner. Thank you very much.

The congresswoman from Rhode Island.

Mrs. Schneider. Mr. Vonier, I wonder if you could please elaborate. In a recent report from the Energy Research Advisory Board, the ERAB report as we refer to it, the comments on conservation research and development suggested that DOE should continue its buildings program. I wondered what your general observations were of that particular recommendation and if you believe, as they do, that we should establish a separate Building Energy Institute to use as a vehicle to get energy conservation and energy efficiency information out.

Mr. Vonier. Certainly I agree with the conclusions reached by ERAB. I think our reluctance at this time to support the recommendation for either the consolidation of the conservation and solar programs or the creation of a separate institute stems more from the impression we have that after the past 2 years there is a certain amount of stability beginning to emerge in the programs at the Department of Energy. To make that step now might undo more than it would do. That is to say that it might be better to wait and see how things go before implementing that recommendation. I think in the best of all worlds that's very much something one would do.

Mrs. SCHNEIDER. Do you not think that perhaps rather than set up a new institute, we could have the National Institute of Building Sciences take over that responsibility?

Mr. VONIER. I think I prefer to answer that question in writing, if I may.

Mrs. SCHNEIDER. OK. That would be fine.

Mr. Carter, I'm wondering if you would summarize in general, please, what role you see the Federal Government playing in energy research and development.

Mr. CARTER. We believe that the high-risk low payback, long-term studies are a very effective way for the Government to enter into this problem. Most of the energy that has been saved to date has been done with some very practical means. Engineers tend to be a rather direct sort of a group. We will attack a problem head on but we do need the long-term research that can be provided by the Government to assist us in this. We see that as the proper role.

Mrs. SCHNEIDER. One of the points that you made that seems to be rather repetitious in this body here is that the Department of Energy is putting together wonderful bits and pieces of information having to do with R&D in all areas, whether it be in photovoltaics or in energy efficiency. But there seems to be a real information gap. How do we get the information from the research laboratories or whatever out into the hands of the architects and the engineers, et cetera? Do you have any ideas as to how to solve that problem?

Mr. CARTER. Yes. Probably in a long discussion we could come up with some ideas that would contribute but in point of truth we are desperate for some of the wonderful information that has come out of the studies in BEPS and in other areas of research.

We have already put a great many of them into practice. I was quite close to BEPS as it went through. I would catch myself time and again going back to a piece of technical information that had been presented at one of the meetings and putting it to practical use. We need somehow to get these ideas out and shared. Some sort of a collating procedure.

Mrs. SCHNEIDER. We all agree on that. But what I am asking for is the solution. That's the thing that we don't seem to be coming up with here.

Mr. CARTER. Why don't we offer a solution to you from our energy committee on that subject and put it to some serious thought. We'll put it in writing and return it to you.

Mrs. SCHNEIDER. OK. That would be greatly appreciated. I think that one of my greatest frustrations is to see factories throughout New England closing down left and right because of high energy costs, while much of it could be solved if some of the manufacturers were aware of the technologies that existed for energy efficiency. If

I didn't sit on this committee, I wouldn't know about what technologies are available, either. I can carry that home to my State, but what about all the other States that have no access to that information? Thank you, Mr. Chairman.

Mr. **Sensenbrenner**. The gentleman from Illinois.

Mr. **Durbin**. Thank you very much.

I want to apologize to the panel in advance. I, like many other members, have another committee, agriculture, in the process of a markup on a bill which I'm cosponsoring so I have to leave very shortly. But I did want to stay long enough to ask a few questions of the panel in general. I come from central Illinois. We are having—and this is understated—some degree of problem with natural gas prices. Where they have risen 24 percent nationwide they have risen 77 percent where I live. I sense that if something isn't done very soon, the Boston Tea Party will look like a love-in by next winter. If we don't address ourselves to some specifics very quickly in Congress, we are going to be held accountable and quite rightly so. The thing that concerns me, as I view the whole energy question, is the disparity in opportunity available to the residential consumer and the industrial consumer. Presently in industry there is still an option: if they can't pay natural gas prices they can consider switching to heating oil or in some circumstances to coal. The residential consumer doesn't have that luxury. If you don't like your natural gas price you can chop wood or freeze. And frankly that's all you have to turn to.

I think we've got to do one of three things, and one of those possibilities relates directly to your testimony this morning. The three things are: Change the natural gas pricing structure in this country; develop some new heat source that is reliable and cheap; or, third, give the residential consumer the luxury which industry to some degree has, and that is a choice.

At the present time I don't know of any technology that is being developed on a local level to give a residential consumer a choice. Then, if natural gas prices are high, there would be a quick change over to another source.

Does anyone see anything on the horizon from a residential viewpoint, particularly for the natural gas consumer, that might provide that opportunity?

Mr. Kensill.

Mr. **Kensill**. There are at least two major areas that we have been considering at this point. The first one is that surprisingly large number of units that are currently set up for gas could actually be made into dual fuel units. Much more than we thought. We've been exploring this in the field and that looks somewhat promising. I think that a second, perhaps crisis-type, intervention that is possible is a number of methods of restricting the amount of the house that is heated. We are testing out a very flexible method of zoning that would be applicable at a very low cost. We have a test installation in Minneapolis/St. Paul, surburban Philadelphia, and urban Philadelphia, and savings of the order of 40 to 60 percent by a combination of retrofits, having a total cost under $600, does appear to be possible. This is a crisis-type situation but it does make it possible for a person to have "breathing room" while they make other changes in their lifestyle. Simply it allows a person to select how much of this house he can afford at any one time in the season to heat; anywhere from one room closed off to one room heated, but without the danger of losing the structure.

Mr. **Durbin**. What do you see as a Federal role in this type of approach? Has there been one?

Mr. **Kensill**. I think the Federal role is essential because, in order to make this thing happen, you have to coordinate an activity working with suppliers, with distributors, with utilities, with installers; there needs to be a role of training; there needs to be a role to set up a way of administering this type of program, and there especially needs to be information.

Mr. **Durbin**. Do you feel though, this will be the classic debate? I'm sure in Congress, that since there will be a consumer demand for some alternatives, that this could not be done by the private sector?

Mr. **Kensill**. I think that the nature of the consumer demand in the heating field is a particularly difficult one because it tends to be a crisis-oriented demand. It means that if someone rushes to market with a product, regardless of what claims they make, if somebody is cold or they can't pay their bill, they'll buy it. The difficulty, then, is that in a certain sense it's like bad money driving out good. People don't take the time to plan. They've got to do it now. Witness the enormous importation of kerosene heaters without any real consideration as to whether this is a good solution or not.

We saw thousands of families that lost a good portion of their house because they couldn't maintain their central heating system after they put a kerosene heater in; the plumbing froze up and they had structural damage to the house. None of these things were they aware of initially. It seems to me there has to be a solid body of information given out. You have to train people to install these things. This takes planning ahead of time. This means that during the summer you have to train the people so that by fall, when the demand exists, the people that do the work also exist.

Mr. **Sensenbrenner**. The gentleman's time has expired.

Mr. **Durbin**. Thank you.

Mr. **Sensenbrenner**. Thank you for your testimony this morning.

We will now go to the second panel.

The second panel consists of the Multisector witnesses. The first witness is Thomas Wilbanks, Associate Director, Energy Division, Oak Ridge National Laboratory, Oak Ridge, Tenn.

The second witness is Bradford Chase, acting under secretary for energy, Office of Policy and Management, State of Hartford Conn.

The third witness is Mr. Craig Marks, executive director, environmental activities staff, General Motors Technical Center, Warren, Mich.

Without objection we will include your printed testimony in the record and request that each of you summarize the points that you have made in the printed testimony.

Mr. Wilbanks, we will now hear from you.

STATEMENT OF THOMAS J. WILBANKS, ASSOCIATE DIRECTOR, ENERGY DIVISION, OAK RIDGE NATIONAL LABORATORY, OAK RIDGE, TENN.

Mr. **Wilbanks**. Mr. Chairman, distinguished members of the committee. I appreciate this opportunity to be with you again. Based on some conversations with your committee staff about your interests in these hearings and the specialties of others scheduled to give testimony, it seemed to me that I might contribute the most by focusing on a cross-cutting issue that's not a line item in the budget, but is an issue that I think is an important part of the general context for your decisions about more specific programs and budgets. In doing this I need to make it clear that I am speaking as a private citizen, not as a representative of the Oak Ridge National Laboratory or the Department of Energy.

Let me introduce this issue by summarizing where we stand with the——

Mr. **Sensenbrenner**. If I can interrupt you, Mr. Wilbanks. The House goes into session at 11 a.m. I anticipate a series of votes on deferral resolutions. So I would ask that each of you summarize your testimony, yours is 11 pages long and the others are about of equal length, so that at least we will be able to get to the questions before all of us disappear to answer the roll.

Mr. **Wilbanks**. I'll certainly not read it all, Mr. Chairman.

I believe it's clear to all of us that energy conservation is important to this country. We know that it has contributed more to our coping with our energy situation the last 9 years than what we've done on the supply side. We have seen patterns of energy use in the United States depart from historical trends. We've learned that economic growth can be maintained without a one-to-one correspondence in energy supply growth. Our studies in the transportation sector, in particular, have shown us that these changes are sustaining themselves, even with the decline in the real cost of energy. We can see the impact of energy conservation on our electric utilities; our natural gas suppliers; the world oil markets—just about everywhere we turn in energy policy. For these reasons and others, it seems to me that our energy supply strategies in the 1980's are going to depend more strongly on our judgments about energy demand conditions than on the characteristics of the supply options themselves.

But I think it can be argued that we have two major problems with energy conservation at this time. First, we don't really understand why it takes place. We know that energy prices are an important factor, of course; but we know that other factors are important as well, such as Government programs. Our problem is that in putting these factors together at this point as a basis for decisions, we know very little—at least with much confidence—about how these factors work, how much they contribute, and why they do what they do—especially when it comes to the nonprice factors. This makes it hard to anticipate the future, to determine appropriate Government roles in conservation, and to assure that Government conservation programs are both effective and efficient.

Second, we know that in many parts of our economy the energy conservation that has taken place so far—impressive as it is—is still considerably less than what makes economic and energy sense, which means that during a time when economic conditions are tough for many individuals and organizations these people are often paying more for their energy services than they need to, which reduces the resources available to them to meet other pressing needs.

These uncertainties about what causes energy conservation and how to bring it about, present us as a society—private and public sectors alike—with an enormous challenge in making good decisions as we consider investments in energy technologies, facilities, and programs. In the case of electricity generation, for instance, adding baseload power generation capacity requires a lead time of at least 6 to 8 years, at a time when a mistake can be very costly indeed. With interest rates still high, adding capacity which is not needed ends up costing ratepayers a lot of money. But failing to add capacity which is needed can also cost ratepayers a lot of money, and it reduces the reliability of electricity supply. In either case, a mistake has the effect of undermining public confidence in the utility, as well as burdening the budgets of users. The stakes are extremely high, in a period when uncertainties are also extremely high. At a time like this, I would argue, it is critically important that we reduce the uncertainties wherever we can by getting better information about the determinants of energy use. This is a national need.

One of the reasons that it is important to reduce our uncertainties about the determinants of energy conservation is that we continue to debate Government roles in conservation. The central issue here is whether relying on a market mechanism is sufficient. Are the barriers to optimizing energy efficiency so great that Government action is required? We all know that barriers do exist: imperfect information about choices, limits on capital availability, and so on. There is considerable evidence that we are still a long way from optimal levels of efficiency, especially in our energy use in buildings. But what we don't know, and what we can't know, based on existing information is how close we are likely to get to realizing these potentials if we depend almost entirely on the market—and how fast we will move in these directions.

But we need to know. The current gap contributes to inefficiencies in our national economy, and it hurts individual families, private firms, and public services. Reducing it can contribute substantially to our economic recovery. For example, a 1981 analysis by Servidyne, Inc., a private firm with offices in 17 American cities, identified a residential energy conservation industry with a market potential of more than $90 billion in current prices. Developing that industry would create almost half a million new jobs—mostly jobs calling for relatively low-skill levels, mostly located where the population is concentrated, offering very real possibilities for reducing unemployment. Is this kind of thing likely to happen because of market forces by themselves? The fact is that we do not know. Rather than continuing to argue such things on the basis of political philosophy alone, it seems to me we should move as quickly as we can to improve the factual basis for making our national energy conservation policy decisions.

To illustrate the potential for this very briefly, I would like to say something about just one issue in making energy use decisions—the role of information which has come up already today; and I would like to orient these comments toward energy use in buildings, which was the subject of the first panel.

In either theory or reality, the efficient functioning of an economic market depends on the universal availability of more or less perfect information. In the case of market decisions about energy use, this means that users should have in their possession complete information about their various options: information which is both reliable and believable. But what we often see, instead, is something very different. The decisionmaking context which is dominated by uncertainty—because information so often seems lacking, conflicting, or confusing—by diversity—meaning that information based on an average situation is unreliable for an individual user—and by skepticism because most of the providers are believed to have axes to grind.

This tells us that, to meet our information needs in connection with energy use in buildings, we need to understand information processes as well as market processes; and there is a large literature available on information processes to help us get started. My written testimony contains some examples of this. Many times these kinds of factors seem obvious once somebody points them out, but sometimes they are more subtle. In a recent evaluation of the Federal energy-related inventions program, for example, some of my colleagues at Oak Ridge found that this program has certainly fulfilled its mandate and helped a number of promising inventions to advance toward commercialization, but the fact that the program provided money to inventors is only one of the reasons for this. As we all know, independent inventors often run into skepticism when they try to raise capital in private markets; some of the people are crackpots, more of them may appear to be, and potential lenders have a hard time making confident judgments about the validity of what is proposed. In this particular case, the evaluations of technology ideas which were performed very ably by the National Bureau of Standards meant an important kind of benefit beyond the DOE grants themselves. They gave a successful applicant credibility and visibility for approaching the private sources of support. They enabled the capital market to work the way it is supposed to, by improving the information available to it.

This, I think, illustrates an important general point: that every government program is an opportunity for us to find out more about what works. Each one is a kind of experiment, even if that is not its purpose, and few turn out exactly as expected or hoped. One of the ways to increase the social value of a program is to try to learn some lessons from it that can be applied to both improving it in midstream and to designing future programs as well. But this is hard to do unless an evaluation effort is built into the fabric of the program from the start.

In any event, the role of information in energy use decisions is important. We know that. But we don't understand very well how to use information to get the energy conservation job done. As a result, our discussions of conservation policy and our implementation of many conservation programs suffer—and they suffer unnecessarily, because many of the missing elements are in fact knowable.

To close this gap between what we need to know about energy use and what we know now, I would suggest that four kinds of options be considered.

The first requirement is to improve our understanding of what's happening in energy use. We need better sets of data, giving us more detail, extending across time to enable us to identify trends. And we need reliable and credible analysis to inform energy decisionmakers throughout society about determinants and trends in energy use.

The Energy Information Administration, of course, is the heart of this effort for the Nation, but its budgets have shrunk to the point where it's having increasing trouble doing just those things that are mandated by law. Data and analysis related to energy use, by the way, are not mandated by law. Sometimes this kind of budget situation can have the effect that roles which are important but not mandated tend to get squeezed out. I think it is important for us to assure that this does not reduce our ability to understand energy use in the United States at the very time when we need so badly to increase that ability.

Second, we need to improve our base of information about which conservation programs work well, which do not, and why. As I mentioned earlier, during a time when it is probably more important than at any other time in American history to perform essential public functions as efficiently as possible, with as small a budget burden as possible, I think we are failing in our responsibilities if we don't make a commitment to learn from our experience.

Third, I'll just refer the committee and the audience to the comments in my written testimony about the need for a social science component in our technology base for energy research and development.

Finally, I need to mention the effect of the current lack of stability in energy research and development on the attempts of all of us in the R&D community to do as good work as we can, to be as much help as we can in solving national energy problems, and to use program support as efficiently as we think we need to if we take our responsibilities seriously as stewards of public trust.

In summary, Mr. Chairman, energy conservation is important to both suppliers and users of energy in the United States. But we need to know more about why conservation occurs. We need to know more because uncertainties about future levels of energy use are putting all kinds of energy investment decisions at risk. We need to know more because the sizable gaps between energy conservation achievements so far and energy efficiencies that seem to make good economic sense, especially in the building sector, are almost certainly hurting people, firms, and public services in this country. And we need to know more because continuing disputes about the need for government roles in energy conservation are detrimental to good government. For these reasons, I would recommend that our base of information and analysis related to the determinants of energy use be strengthened.

Thank you, sir.

[The prepared statement by Mr. Wilbanks follows:]

THOMAS J. WILBANKS

Energy Division
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

TESTIMONY

Presented to the Subcommittee on Energy Development
and Applications, Committee on Science and Technology
U.S. House of Representatives

Hearings on Issues Associated with Energy
Conservation Research and Development Programs

March 10, 1983

TESTIMONY TO THE U.S. HOUSE COMMITTEE
ON SCIENCE AND TECHNOLOGY
MARCH 1983

MR. CHAIRMAN, DISTINGUISHED MEMBERS OF THE COMMITTEE:

I appreciate this opportunity to meet with you again and to be a part of your discussion of such an important subject. Based on conversations with the Committee staff about your interests in these hearings and the specialties of others scheduled to give testimony, it seemed to me that the most useful contribution I could make might be to raise a few broad issues that I think are an important part of the general context for your decisions about more specific programs and budgets. In doing this, I need to make it clear that I am speaking as a private citizen, not as a representative of the Oak Ridge National Laboratory or the Department of Energy.

A. Where We Stand with Energy Conservation

It is quite clear that the most significant changes in the U.S. energy system since the 1973 oil embargo have been in energy use, not energy supply. Between 1973 and 1981, our energy use per unit of GNP dropped 18%, and as a consequence our total primary energy use in 1981 was slightly lower than it had been in 1973. Compared with an extension of pre-1973 trends, energy use in 1981 had been cut by 28 quadrillion Btu's (quads) or nearly 30 percent. This quantity is substantially larger than the total amount of energy supplied in this country each year by either domestic petroleum, total gas fuels, or total energy from coal. As a result, even though the reasons for this change include a reduced rate of economic growth as well as energy conservation, the value of conservation is no longer a major public policy issue in the United States.*

We all know that conservation is important. We know that patterns of energy use in the United States have departed from historical trends; we have learned that economic growth can be maintained without a one-to-one increase in energy supply growth; and our studies of the transportation sector in particular show that these changes are sustaining themselves even with a decline in the real cost of energy. We can see the impact of energy conservation on our electric utilities, our natural gas suppliers, the world oil market--just about everywhere we turn in energy policy. For these reasons and others, it seems to me that our energy supply strategies in the 1980's are going to depend more strongly on our judgments about future energy demand conditions than on our judgments about the relative merits of different supply options themselves.

B. Where We Have Problems with Energy Conservation

But I think it can be argued that we have two major problems with energy conservation at this time: (1) We don't really understand why it takes place. We know that energy prices are an important factor, of course; but we know that other factors are also important, such as government programs. The problem is that, in putting these factors together at this point, we know very little (at least with much confidence) about how, how much, and why--especially when it comes to the non-price factors.

---

*See E. Hirst, R. Marlay, D. Greene, and R. Barnes, "Recent Changes in U.S. Energy Consumption: What Happened and Why," Annual Review of Energy, forthcoming.

This makes it hard to anticipate the future, to determine appropriate government roles in conservation, and to assure that government conservation programs are both effective and efficient. (2) We know that, in many parts of our economy, the energy conservation that has taken place so far--impressive as it is--is still considerably less than what makes economic and energy sense, which means that during a time when economic conditions are tough for many individuals and organizations these people are often paying more for their energy services than they need to, reducing the resources available to them to meet other pressing needs.

Let me elaborate just a bit on each of these problems. We know that the changes in energy use in the past nine years are partly a consequence of slower economic growth and partly a consequence of energy conservation. And we know that a conservation is partly the result of higher prices and partly the result of a variety of other factors: longer-term trends in technological change, the substitution of less energy-intensive goods and services for more intensive ones, government and utility conservation programs, differences between the perspectives of energy end-users and various intermediaries, and other things. We certainly know more than we did ten years ago. But we do not know very much yet about the specific roles of these separate factors--enough so that, for example, we can predict with some confidence what will happen to U.S. energy use as the economy recovers, or whether government conservation policies are more or less effective--or more or less needed--when energy prices drop than they are when energy prices are rising.

This presents us as a society--private and public sectors alike--with an enormous challenge in making good decisions as we consider investments in energy technologies, facilities, and programs. In the case of electricity generation, for instance, adding baseload power generation capacity requires a lead time of at least six to eight years, at a time when a mistake can be very costly indeed. With interest rates still high, adding capacity which is not needed ends up costing ratepayers a lot of money. But failing to add capacity which is needed can also cost ratepayers a lot of money, and it reduces the reliability of electricity supply. In either case, a mistake has the effect of undermining public confidence in the utility, as well as burdening the budgets of users. The stakes are extremely high, in a period when uncertainties are also extremely high. At a time like this, I would argue, it is critically important that we reduce the uncertainties wherever we can by getting better information about the determinants of energy use. It's a national need.

One of the reasons that it is important to reduce our uncertainties about the determinants of energy conservation is that we continue to debate government roles in conservation. The central issue is whether relying on the market mechanism is sufficient. Are the barriers to optimizing energy efficiency so great that government action is required? We all know that barriers do exist: imperfect information about choices, limits on capital availability, inertia, institutional and regulatory constraints, and others. And there is considerable evidence that we are still a long way from optimal levels of efficiency, especially in our energy use in buildings; one can point to studies by the Mellon Foundation, OTA, evaluations of the energy audit experience at the Oak Ridge National

Laboratory, and evaluations of market potentials by private industry. What we don't know, and cannot know based on existing information, is how close we are likely to get to realizing these potentials if we depend almost entirely on the market--and how fast we will move in those directions.

But we need to know. The current gap contributes to inefficiencies in our national economy, and it hurts individual families, private firms, and public services. Reducing it can contribute substantially to our economic recovery. For example, a 1981 analysis by Servidyne, Incorporated, a private firm with offices in seventeen American cities, identified a residential energy conservation industry with a market potential of more than $90 billion in current prices. Developing that industry would create almost half a million new jobs--mostly jobs calling for relatively low skill levels, mostly located where the population is concentrated, offering very real possibilities for reducing unemployment. Is this kind of thing likely to happen because of market forces by themselves? The fact is that we do not know. Rather than continuing to argue such things on the basis of political philosophy alone, it seems to me that we should move as quickly as we can to improve the factual basis for making our national energy conservation policy decisions.

C. The Potential for Solving These Problems

To illustrate the potential for this very briefly, I would like to draw on two bodies of recent experience: (1) the draft report of a committee of the National Research Council, of which I am a member,* and

---

*Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Academy of Sciences/National Research Council. The report is presently undergoing Academy review; the opinions expressed here are my own, not necessarily those of the Committee or NAS/NRC.

(2) a number of evaluations of energy conservation-related programs conducted in the past several years at the Oak Ridge National Laboratory. These pull together some insights based not on supposition but on observations of actual human and organizational behavior. To keep from going on too long, I will orient my comments toward energy use in buildings, because--as you know--the Energy Research Advisory Board (ERAB) has identified this as the highest priority for a federal role, OTA has suggested that the potential for further energy savings is huge, and many observers have indicated that this is the energy use sector where the barriers to economic stimuli are the greatest. And I will limit my comments to one issue in understanding energy use in buildings: the role of information in energy use decisions.

Whether in theory or reality, the efficient functioning of an economic market depends on the universal availability of more or less "perfect" information. In the case of market decisions about energy use, this means that users should have in their possession complete information about their various options: information which is both reliable and believable. But what we often see, instead, is a decisionmaking context which is dominated by uncertainty (because information so often seems lacking, conflicting, or confusing), diversity (meaning that information based on an "average" situation is unreliable), and skepticism (because most of the providers are believed to have axes to grind). For instance, a given fact may be evaluated differently by a user depending upon where it comes from.

This tells us that, to meet our information needs in connection with energy use in buildings, we need to understand information processes as well as market processes; and there is a large literature available on information processes to help us get started. For instance, this literature suggests such things as the following: that users understand messages about energy efficiency better if they are stated in terms of simple, understandable indexes (gallons per mile may mean something, but seldom kilowatt hours per heating degree day); that users save more energy when energy flows are made more visible, such as by display meters; that the demand for home audits depends on the methods of publicizing an audit program, and actions taken as the result of an audit depend on how the results are communicated; that information is more often acted upon when it comes from a trusted source; and that it is more often acted upon when the user is protected from the risks associated with uncertainty, diversity, and skepticism.

Many times, these factors seem obvious once somebody points them out, but sometimes they are more subtle. In a recent evaluation of the Federal Energy-Related Inventions Program (ERIP), for example, some of my colleagues at Oak Ridge found that this program has certainly fulfilled its mandate and helped a number of promising inventions to advance toward commercialization, but the fact that the program provided money to inventors is only one of the reasons. As we all know, independent inventors often run into skepticism when they try to raise capital in private markets; some of the people are crackpots, more of them may appear to be, and potential lenders have a hard time making confident judgments about the validity of what is proposed. In this particular case, the evaluations of technology ideas performed very ably by the National Bureau of Standards meant an important kind of benefit beyond the DOE grants themselves. They gave a successful applicant credibility and visibility for approaching private sources of support. They enabled the capital market to work by improving the information available to it.*

This, I think, illustrates an important general point: that every government program is an opportunity for us to find out more about what works. Each one is a kind of experiment, even if that is not its purpose, and few turn out exactly as expected or hoped. One of the ways to increase the social value of a program is to try to learn some lessons from it that can be applied both to improving it in midstream and to designing future programs as well. But this is hard to do unless an evaluation effort is built into the fabric of the program from the start.

In any event, the role of information in energy use decisions is important. We know that. But we do not understand very well how to use information to get the energy conservation job done. As a result, our discussions of conservation policy and our implementation of many conservation programs suffer--and they suffer unnecessarily, because many of the missing elements are in fact knowable.

D. What Needs to Be Done.

To close this gap between what we need to know about energy use and what we know now, I would suggest that four kinds of options be considered:

(1) Data and analysis. The first requirement is to improve our understanding of what's happening in energy use. We need better sets

---

*M. G. Rorke, L. M. Bronfman, and E. J. Soderstrom, "Evaluation of the Energy-Related Inventions Program," ORNL/CON-92/v.1, Oak Ridge National Laboratory, February 1983.

of data, giving us more detail, extending across time to enable us to identify trends. And we need reliable and credible analysis to inform energy decisionmakers throughout society about determinants and trends in energy use. In these ways, we can reduce many kinds of uncertainty that are getting in the way of solutions to national energy problems.

The Energy Information Administration (EIA), of course, is the heart of this effort for the nation, and their data sets are widely used by the private sector as well as the public sector. It is easy to show that, say, when many utilities and other decisionmakers need information about trends in energy use, EIA can offer substantial economies of scale in meeting this need, compared with a situation where the separate groups are having to gather all of their own information. But data and analysis related to energy use are not mandated by law. When an agency such as EIA, or the conservation part of DOE for that matter, sees its budget shrink to the point that even its mandated roles can hardly be played, other roles that may be at least as important but are not specifically mandated tend to get squeezed out. I think it is important to assure that such a situation does not reduce our ability to understand energy use in the United States at the very time when we need very badly to be increasing that ability.

(2) Program evaluations. Secondly, we need to improve our base of information about which conservation programs work well, which do not, and why. As I mentioned earlier, during a period when it is probably more important than at any other time in American history to perform essential public functions as efficiently as possible, with as small a

budget burden as possible, I think we are failing in our responsibilities if we do not make a commitment to learn from our experience. But, as I also said, we cannot expect to be able to do this unless we assure that the necessary information will be available and that the evaluations can be performed in a constructive, non-threatening environment.

(3) Social science research support. Thirdly, our efforts to understand energy use in the United States rest on a "technology base," just as do our efforts to develop such options as synthetic fuels from coal; but we need to recognize that this part of our technology base has been neglected, because it involves research of a different kind. ERAB's 1981 report on R&D priorities said: "Our energy system is a web of machines and people; the current budget is focused on machines" alone. As a result, we have an R&D support structure that prepares us to answer questions about machines, not people, even though it is pretty widely agreed that our most fundamental energy problems are not technological. More than four years ago, I pointed out that the social sciences are the only major category of the sciences in which DOE funds applied work but not fundamental research. This is still true, and our understanding of energy use in the United States is one of the victims of this oversight.

(4) Conditions for work on these issues. Finally, I would be remiss if I failed to bring to your attention one more time the corrosive effects of continuing budget uncertainties on any attempts to pursue work on these or any of a variety of other energy issues. To quote some testimony before this committee last June by Herman Postma, Director of ORNL, "broad national goals are established, then abolished; the federal

role is always under question and...always changing; the role of [particular institutions] in the whole process is never entirely agreed upon; and ...programs are created in patchwork fashion as a consequence." The resulting lack of stability for research and development prevents us all from doing work that is as good as we want, from being as much help in solving national problems as we want to, from using program support as efficiently as we need to if we take our responsibilities seriously as stewards of the public trust. This problem is certainly not unique to energy conservation, but it is one of the many factors that needs attention as we all try to do better.

In summary, Mr. Chairman, energy conservation is important to both suppliers and users of energy in the United States. But we need to know more about why conservation occurs. We need to know more because uncertainties about future levels of energy use are putting all kinds of energy investment decisions at risk. We need to know more because the sizeable gap between energy conservation achievements so far and energy efficiencies that seem to make good economic sense, especially in the buildings sector, are almost certainly hurting people, firms, and public services in this country. And we need to know more because continuing disputes about the need for government roles in energy conservation are detrimental to good government. For these reasons, I would recommend that our base of information and analysis related to the determinants of energy use be strengthened.

BIOGRAPHICAL SKETCH

Thomas J. Wilbanks

Dr. Wilbanks is Associate Director and Head of Programs and Planning for the Energy Division of the Oak Ridge National Laboratory. Formerly a member of the faculties of Syracuse University and the University of Oklahoma, he is the author or co-author of numerous books, papers, and reports on energy policy, energy technology assessment, and decision-making; and he serves frequently on national committees and panels. He is currently a member of the Committee on Behavioral and Social Aspects of Energy Consumption and Production, National Academy of Sciences/National Research Council.

Mr. **Sensenbrenner**. Thank you, Mr. Wilbanks. The next witness will be Mr. Bradford Chase.

STATEMENT OF BRADFORD CHASE, ACTING UNDER SECRETARY FOR ENERGY, OFFICE OF POLICY AND MANAGEMENT, STATE OF CONNECTICUT

Mr. **Chase**. Thank you, Mr. Chairman.

I am Bradford Chase, Acting Under Secretary for Energy in the Connecticut Office of Policy and Management.

It's a pleasure to be here and I certainly appreciate the opportunity to testify on the Energy Extension Service program. I understand the committee's interest is in understanding the impact of Federal funding cutbacks to the Energy Extension program. I provided to you written testimony. I would like now to briefly summarize that as we go forward.

Mr. Chairman, I have been in State government 20 years. I have been in the energy area since 1975; first running general conservation programs; then as director of the pilot program in Connecticut—the Energy Extension Service program. I was then responsible for the administration of all conservation programs for the State of Connecticut and now I head that agency. As you may well know, Connecticut is a small and urbanized State and we rely heavily upon petroleum. To us a major strategy in our energy policy is conservation. Our latest annual survey of Connecticut residents indicates that they continue to view energy as a serious problem. The survey also shows that Connecticut residents have made numerous improvements to conserve energy over the past year.

We credit this in part to the continuing efforts of our conservation education outreach efforts.

In 1977 Connecticut was selected as 1 of 10 pilot States. EES was conceived, designed, and administered as an integral part of a larger statewide energy conservation program.

As you know, the State Energy Conservation Program or SECP was designed to satisfy five federally mandated measures.

The EES program was designed to be an outreach program. It met the demands of small energy users by offering technical, individualized one-on-one grassroots programs. The approach was to use the existing structure to find ways of changing attitude, knowledge, and behavior. Connecticut's funding for EES has decreased dramatically over the the past 5 years. The second program that was designed to be integrated with the Energy Extension Service was the supplemental State Energy Conservation Program or SSECP. SSECP provided statewide distribution of general conservation information. These three programs EES, SECP and SSECP as I indicated, were planned and administered as one unit in the State of Connecticut.

Funding under the EES pilot program was $1.5 million over an 18-month period. That program has been cut now to about $150,000 per year.

Connecticut's funding for the other energy conservation programs was declining at the same time. SECP program decreased about 50 percent and the SSECP is zeroed out.

Let's look at the impacts of these funding reductions on Connecticut's EES programs. In 1977 Connecticut's EES program involved several State agencies conducting 11 different energy conservation programs. The programs were designed primarily to provide one-on-one assistance to a variety of target groups—the small business community, municipalities, nonprofit organizations, schoolchildren, urban neighborhoods, and the general public.

In my testimony, on several pages, I have listed the kinds of accomplishments of those programs. There is an evaluation done by the Department of Energy on the pilot phase programs. I will skip over that part of the testimony because of the time constraint, Mr. Chairman, and indicate that that program for the last 5 years has been declining in activity because of the declining Federal support. In 1977 we had eight county offices providing general outreach of information. In 1981 we were down to four. Today we have none.

Impacts of Federal funding cuts are far greater than just EES, however, because similar pressures were causing reductions in conservation programs as a whole. This has had a significant impact on the solar technical renewable area and particularly in our agency's technical capability which has almost totally been lost.

I think as you read the testimony and look at the chart, which I will hold up, which provides an indication of the funding, Mr. Chairman, from 1977 to 1980 to 1983, indicating the level of funding by program, it will be clear. This is attached to my testimony as appendix IV.

I think the committee and the American people should legitimately ask the question: What did we get for the expenditure of Federal dollars in the EES program in Connecticut for the past 5 years? My answer is a bargain. I believe programs funded by EES contributed significiantly to changing attitudes and behaviors about the use of energy resources in our State. Thousands of people learned, understood, and took conservation action in their homes and businesses. I measure this in part by the fact that the total energy use in Connecticut declined by 22 percent between 1978 and 1981, and oil dropped by 30 percent during the same period.

In summary, Mr. Chairman, in 1977, and for several years thereafter, the Federal Government asked the States to play a major role in helping solve what was viewed as a national energy problem. Based on Federal funding the States became key delivery mechanisms for energy conservation information and assistance. The States established staffs, experimented with and developed new ideas, had successes and failures and then finally turned their activities into effective conservation programs. Then national policy suddenly changed, funding support decreased, leaving the States to respond to established constituencies with limited resources.

Staff capabilities at the State level have been severely impacted; in addition to reductions in the number of staff, specialists have been lost as well.

Innovative applications about conservation motivation is almost dormant.

Complacency about the energy problems is returning.

Assistance available on renewable resource development and use has decreased substantially.

The one-on-one information outreach found to be effective has now been replaced with a general outreach effort.

Information developed earlier is becoming dated in the wake of fast moving technology.

States are now scrambling to rearrange program priorities to match funding sources which may or may not meet servicing needs; many programs have been dropped outright—some have been transferred.

Utilities are playing a much larger role now in energy conservation.

The impact of Federal energy conservation funds cutbacks has indeed been significant to us in Connecticut and in the other New England States. Over the last 7 years EES, SECP, and SSECP were major forces in our State which served to help our citizens cope with rising energy prices. We've committed ourselves as a State to an emphasis on conservation as a major building block of our State's energy policy. We've contributed to solving the national energy problem by developing new ideas, testing and molding programs, and sharing our experience with others.

I believe the level of Federal support will directly translate into how effective we are as a people in solving our energy problems.

I might mention, as an aside, listening to the previous testimony the answer to the question of how does the information get from the source to the user was not answered. I submit to you that that is an important role that Federal funding can provide the State to inform, to stimulate, to motivate, to coordinate, to evaluate, to experiment, and to provide a framework.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Chase follows:]

STATEMENT
BEFORE THE
HOUSE SUBCOMMITTEE
ON
ENERGY DEVELOPMENT AND APPLICATIONS

MARCH 10, 1983

PRESENTED BY
BRADFORD S. CHASE
ACTING UNDER SECRETARY FOR ENERGY

OFFICE OF POLICY AND MANAGEMENT
STATE OF CONNECTICUT

Comments Before the House Subcommittee on Energy Development and Applications

Bradford S. Chase, Acting Under Secretary for Energy

Connecticut Office of Policy and Management

March 10, 1983

Good morning, Mr. Chairman and members of the committee. I am Bradford Chase, Acting Under Secretary for Energy in the Connecticut Office of Policy and Management. It is a pleasure to be here this morning testifying on the Energy Extension Service program.

I have been associated with this program since the pilot program began in 1977, and I am pleased to have been asked to share my views with you. As background, in my position, I am responsible for energy policy work, energy emergency preparedness, and energy program implementation in the State of Connecticut. The latter aspect of my responsibilities, the conduct of energy conservation programs and the relationship between the federal Energy Extension Service program and Connecticut's efforts in the conservation area are of particular concern to you here today.

Connecticut is a relatively small but urbanized state devoid of traditional fossil fuel resources. Our location causes us to rely more heavily on imported petroleum and less on natural gas and coal than the United States as a whole. As a result, our energy costs reflect high-priced oil and expensive transportation costs which historically have been well above the national average. In 1981, for example, natural gas was 34% above the national average, residual oil was 15% higher, and electricity was 44% higher. (See Appendix I.)

Connecticut's profile of energy use also varies somewhat from the national average when analyzed by end use sector. In particular, Connecticut's residential sector consumes 28.6% of the total amount of energy consumed in the state while the national average for residential sector consumption is only 20.1%. Connecticut's commercial and industrial sectors constitute only 36.4% of total state energy consumption; nationally these sectors consume 44%.

Given Connecticut's critical needs for energy and the relatively high price of energy, over which we have little or no control, we have turned to conservation as the most effective and expedient way to deal with our energy problems. Our conservation programs have helped Connecticut citizens and businesses reduce their energy consumption while we continue to increase our population and business activity. Total energy consumption in Connecticut declined 23% from 1977 to 1981. In the residential sector, consumption declined by 14%; 10% in transportation. (See Appendix II.) The commercial and industrial sectors decreased much more drastically, although the national economic downturn is considered to have had more of an impact on energy consumption than conservation in the business sector.

Our latest annual survey of Connecticut residents indicates that they continue to view energy as a serious problem. 65% of the people polled consider the energy crisis "serious" or "very serious." One-third think it is "very likely" that we will have another fuel shortage within the next 5 years; another third considered a shortage "somewhat likely."

The survey also showed that Connecticut residents have made numerous improvements to conserve energy over the past year. 36% caulked and weatherstripped; 12% added storm doors and windows; 10% added attic insulation. The graph attached as Appendix III shows the extent of implementation of a number of common conservation measures.

While a direct correlation between the above-mentioned conservation activity and the Energy Extension Service and other conservation programs is difficult to quantify, the history of the programs which I am about to discuss demonstrates cause and effect relationships.

In order to understand the impacts of changes in the EES program, we must start by putting it in the proper perspective. In 1977, Connecticut was selected to be one of the 10 EES Pilot states. EES was conceived, designed, and administrered as an integral part of a larger statewide energy conservation plan. The overall plan, under the jurisdiction of one supervisor, incorporated a number of programs funded under EES, the State Energy Conservation Plan (SECP) and the Supplementary State Energy Conservation Plan (SSECP).

As you know, SECP was designed to satisfy the 5 federally-mandated measures. Its purpose was to have significiant impacts on energy conservation activities in major segments of the population.

EES was designed to be an outreach program. It met the demands of the small energy user by offering technical, individualized one-on-one grass roots programs. The approach was to use existing local, neighborhood groups to reach the target audiences. It was a longer term design to raise the awareness of the public to affect positive attitudinal and behavioral changes about energy consumption patterns.

The SSECP efforts were to be supplement and complement the EES and SECP programs. It provided statewide distribution of general conservation information through newspapers, publications, fact sheets, etc.

Connecticut's funding for EES has decreased dramatically over the past 5 years. Under the pilot program, Connecticut received $1.5 million for an 18-month period. Funding under the subsequent national program, decreased, as we had anticipated from the beginning. However, funding levels have continued to decline; our 1982 grant amounted to less than $150,000. (See Appendix IV.)

Connecticut's funding for other energy conservation programs was declining simultaneously. SECP funding decreased about 50% from $632,000 in 1978 to $358,000 in 1982. SSECP funding, which peaked in 1978 at $359,000 has been discontinued. (See Appendix IV.)

I would now like to turn to the impacts of these funding reductions on Connecticut's EES programs. The most effective way to portray these impacts is to compare the original conservation programs with the programs as they exist today.

In 1977, Connecticut's EES program involved several state agencies conducting 11 different energy conservation programs. The programs were designed to provide one-on-one assistance to a variety of target groups -- the small business community, municipalities, non-profit orgranizations, school children, urban neighborhoods and the general public.

The Small Business Energy Service began in 1977 under joint sponsorship with the State Department of Economic Development. The service consisted of 3 programs -- workshops, free Class A energy audits and technical information. We worked with existing business organizations to disseminate information and publicize the availability of the services to Connecticut's 30,000 small businesses. The Small Business Energy Service was well received: at the height of the program, 5 engineers completed 752 audits in a year; our evaluations show that 80% of the companies audited implemented at least some of the audit recommendations.

From the hundreds of fine examples of dollars saved as a result of the Small Business Energy Service audits, I would like to cite just one to illustrate the success of the program. A furniture frame company in Glastonbury, CT., requested an audit in 1978. Upon receiving the recommendations of the auditor, the owner invested $56,000 in weatherstripping, replacing incandescent lights with fluorescent, replacing the boiler and recirculating heated exhaust air. Three years later, the capital costs were fully recovered and the company was saving $13,000 annually in electricity and fuel costs. The owner commented that he appreciated the audit because he knew the recommendations were unbiased. He also said the company probably would have gone out of business if he hadn't been able to reduce his energy costs. I have attached details of this experience in Appendix V.

The Small Business Energy Service has had to cut back over the past 2 years. While about 2500 audits have been completed over the past 5 years, our current goal for the one full time and one half time engineers remaining amount to only about 150 audits per year. The 2500 companies that have been audited amount to only one-twelfth of the small business community in the state. It is unfortunate that the budget cuts have occurred simultaneously with a period when small businesses are failing at the fastest rate since the Great Depression.

Connecticut's original EES program also included a municipal component. Working with the State Department of Administrative Services, 128 free technical audits and 451 site visits were conducted in municipal buildings over a 2 year period. Consumption monitoring systems and town energy committees were established in each of the state's 169 towns. These services have been terminated. Now we are only able to assist municipalities through the Schools and Hospitals program, which covers only certain buildings in a limited number of towns.

Another component of the original EES program was the Energy Info-Line. A toll-free line was open to all of Connecticut during normal business hours. Staff screened calls, sent out publications and made referrals. Two other technical staff people provided answers to technical questions, helped callers deal with specific residential energy problems and produced technical fact sheets on common problems. Over 6,000 calls were logged during the first phase of the program. Budget cuts have reduced the service to one non-technical staff person who distributes publications and makes referrals; we lack the manpower and technical expertise to continue producing fact sheets. The Info-Line is staffed only 3 hours per day.

Another major component of the original EES program was Energy Outreach, sponsored jointly by the Energy Division and the University of Connecticut's Cooperative Extension Service (CES). Eight county offices were staffed and services were provided on a statewide basis.

The Urban Program provided training workshops for inner-city neighborhoods. The Energy Audit Program completed 1,000 Class B audits. The Public Information program offered technical information on energy conservation and renewable energy sources. We worked with youth groups -- boy scouts, girl scouts, schools. 745 workshops were held, drawing 55,000 attendees. Exhibits were set up at energy fairs and viewed by 150,000 attendees. The Energy Outreach staff developed a reputation for providing the most up-to-date, unbiased technical energy information in the state.

The University of Connecticut's Engineering Department, under contract with CES, conducted a greenhouse program. They held 5 workshops and completed 35 on-site visits.

By 1981, we were down to 4 county offices each staffed by one professional staff person. It became virtually impossible to provide "one-on-one" assistance and we started looking for ways to stretch staff hours to continue to provide statewide coverage. This resulted in the initiation of the networking approach in 1982. The idea was to develop the capabilities of existing organizations to provide their constituencies with technical energy information. It worked -- many groups -- environmental organizations, schools, community groups, corporate employee programs -- joined in and began providing their members with useful, technical information on energy conservation and renewable resources. The key to networking is that it will continue only as long as there are resource people available to keep feeding these groups up-to-date information and to answer their questions.

The networking process also resulted in the establishment of a new non-profit educational organization called CONNECT -- the Connecticut Energy Council for Teachers. CONNECT was formed by a group of Connecticut teachers, with the help of Energy Outreach, to assist educators in bringing energy topics into the classroom. Their first annual conference drew 150 teachers (on a school day) to learn about Connecticut's energy situation and methods developed by individual teachers to incorporate energy into cirriculum for science, math, economics, home economics, and social studies courses. A quarterly newsletter will keep members up dated on new developments and classroom projects. CONNECT will continue, but it is an exception rather than the rule. Most groups reached through the networking effort do not have the technical capability to folow up on what they have begun.

Energy Outreach had to be discontinued on December 31, 1982 because the fiscal year '82 funds were insufficient to maintain the effort.

I think that hearing this brief EES history, it is clear what a dramatic impact the funding cuts have had on the type and level of EES programming in Connecticut.

As I memtioned earlier, the impacts of the funding cuts are far greater than just EES because similar pressures were causing reductions in conservation programming as a whole.

Our agency's technical capability has almost totally been lost. This has eliminated technical research in support of our toll-free line, the technical fact sheets distributed to the public and our ability to deal with the pressing issue of the outdated energy conservation portion of the building code.

Most of the current solar work is now being done by small solar businesses. Because of their size, exchange of information about innovation is difficult. Without a current state-of-the-art technical information exchange and out reach effort opportunities for rapid growth of the solar industry are limited.

The Connecticut Technical Energy Service, which is a unique program to provide voluntary testing and distribution of summary reports on energy conservation products in Connecticut has been delayed. Efforts to transfer the responsibility of the program to continue the effort have not been very successful.

For 3 years, the Energy Division sponsored a major technical energy information exchange through a regular forum series for commerce, industry, and municipalities in Connecticut. Forty forums were held on 13 energy topics and drew a total of 1,600 people. Our surveys indicate a strong need to continue the series. The last forum held in the state was 16 months ago.

Connecticut also ran a gasoline conservation awareness program to provide training for instructors in fuel efficient driving and planning skills. The minimum potential savings for state agencies in Connecticut was $500,000. The state agency participation program was not completed and the schedule to train private fleet operators was dropped.

The New England states have always been very closely aligned through several organizations. At this point the New England Solar Energy Coalition and the New England Regional Commission no longer exist and the role that DOE Region I has been able to play in this area has been diminished because of their cutbacks. The co-ordination and dissemination of regional technical data, the capability for inter-state exchange of information about activities and general programmatic co-ordination are extremely important, especially in New England where we share such similar experiences concerning energy matters.

The Committee and the American people should legitimately ask the question - what did we get from the expenditure of federal dollars on the EES program in Connecticut these past 5 years? My answer is a bargain. I believe the programs funded by EES contributed significiantly to changing attitudes and behaviors about the use of energy resources in our state. Thousands of people learned, understood and took conservation action in their homes and businesses. I measure this in part by the fact that total energy use in Connecticut declined by 22% between 1978 and 1981, and oil use dropped by 30% during the same period.

A survey of 70 New England energy experts conducted by the New England Energy Congress last year found that they believe conservation should be the single most important energy goal for the region during the next five years. People in Connecticut believe this and are still taking conservation actions. As seen in our most recent oil supply/demand outlook report, oil sales in Connecticut for the period covering this past July through January, adjusted for the weather, declined significiantly over the same period one year ago. It appears that despite the warmer weather we have had in Connecticut this year, consumers are still showing signs of conserving fuel oil.

I attribute this continued conservation, in part, to our energy information and outreach activies which are directed at developing a sensitivity to energy considerations in the decision-making and every day behavior of our citizens. How long this sensitivity, and conservation convictions in general, will survive, particularly in the face of the short term relief we are now finding in the form of lower oil prices, will be a product of how well we did our educational job previously and how much we can continue. Our ability to continue is indeed limited particularly in light of recent federal energy conservation funding cutbacks, not only in EES, but in all the energy conservation programs. What is the impact of the federal funding cutbacks on a mediumsize state like Connecticut? I would like to conclude my remarks today by making several observations in this regard:

In 1977, and for several years thereafter, the federal-government asked the states to play a major role in helping to solve what was viewed as a national energy problem.

Based on federal funding, the states became the key delivery mechanisms for energy conservation information and assistance. The states established staffs, experimented with and developed new ideas, had successes and failures and then finally turned their activities into effective conservation programs. The national policy suddenly changed, funding support decreased leaving the states to respond to established constituencies with limited resources.

- Staff capabilities at the state level have been severely impacted; in addition to reductions in the number of staff, specialists have been lost as well
- Innovative applications about conservation motivation is almost dormant
- Complacency about the energy problems is returning
- Assistance available on renewable resource development and use has decreased substantially
- The one-to-one information outreach found to be effective has now been replaced with a general outreach effort
- Information developed earlier is becoming dated in the wake of fast moving technology
- States are now scrambling to rearrange program priorities to match funding sources which may or may not meet servicing needs; many programs have been dropped outright - some have been transferred.
- Utilities are playing a much larger role now in energy conservation

The impact of federal energy conservation funds has indeed been significant to us in Connecticut and in the other New England states. New England states have many common energy concerns which previously were coordinated, analyzed and studied by specific regional bodies which no longer exist. The New England states miss these resources and feel less effective in knowing, understanding and being able to react to regional energy problems.

Over the last seven years EES, SECP, and SSECP were major forces in our state which served to help our citizens cope with rising energy prices. We've committed ourselves as a state to an emphasis on conservation as a major building block of our state's energy policy. We've contributed to solving the national energy problem by developing new ideas, testing and molding programs and sharing our experiences with others.

In the previously mentioned survey, 70% of Connecticut residents indicated their homes could be made more energy efficient - this is the scale of the energy conservation job to be done in our state. We had the makings of an effective system to help these residents as they set out to address their specific energy concerns.

I believe the level of federal support will directly translate into how effective we are as a people in solving our energy problems.

Thank you Mr. Chairman.

APPENDIX I

Average Energy Prices in Connecticut and in the U.S.

Year	Heating Oil ¢/gal		Natural Gas $/mmBtu		Electricity ¢/kwh		Residual Oil $/barrel	
	CT	U.S.	CT	U.S.	CT	U.S.	CT	U.S.
77	50.5	46.0	3.78	2.26	4.2	3.4	15.23	13.23
78	52.9	49.4	3.91	2.63	4.3	3.7	14.75	12.75
79	86.6	65.6	4.15	3.23	5.0	4.0	22.24	18.67
80	101.0	97.8	4.99	3.95	6.1	4.7	30.79	26.09
81	125.6	120.5	6.11	4.56	7.9	5.5	37.21	32.50

Source: Connecticut Energy Data, 1/83, Conn. Energy Division
and Monthly Energy Review, 1/83, U.S. Department of Energy

APPENDIX II

Connecticut

Energy Consumption by Sector

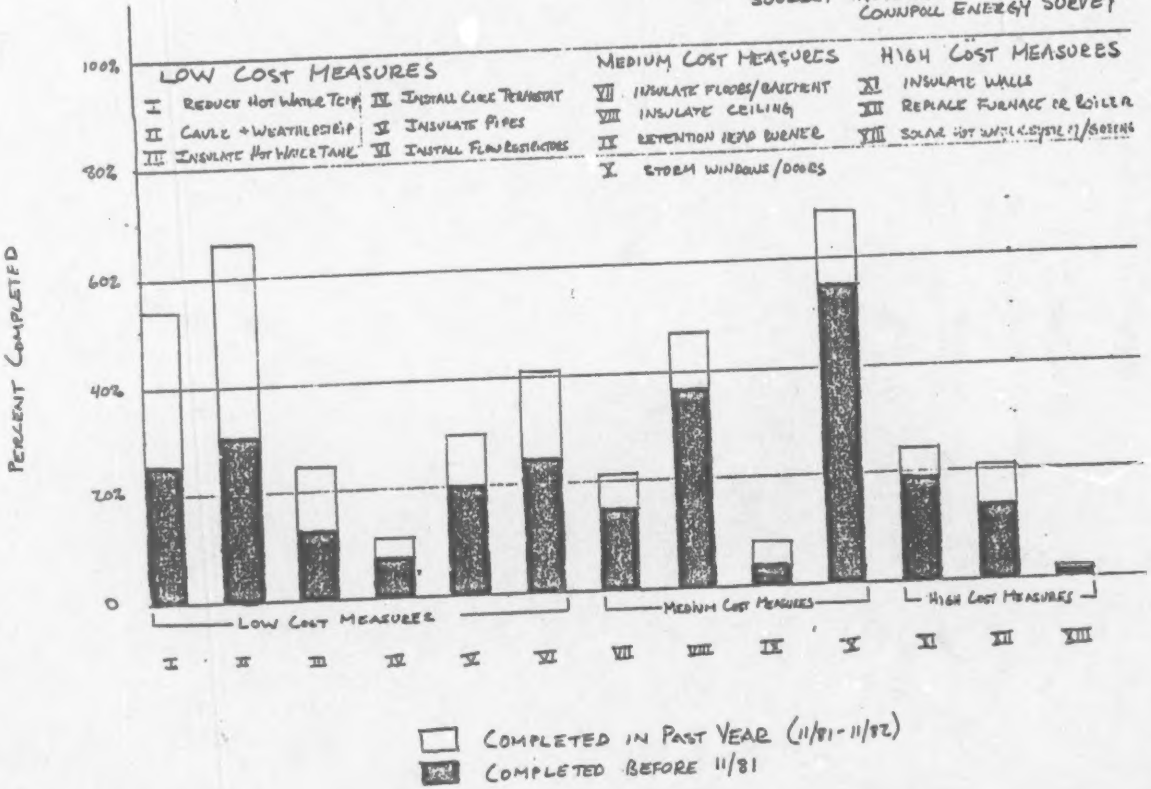
in trillion Btu

Year	Total	Residential	Commercial	Industrial	Transportation
77	600.2	164.2	92.1	140.7	203.2
78	617.6	164.8	95.0	152.9	204.9
79	553.1	164.9	87.0	103.6	197.6
80	505.4	142.4	70.1	103.1	189.8
81	460.5	140.8	70.9	66.7	182.1

Source: Connecticut Energy Data, 1/83, Connecticut Energy Division

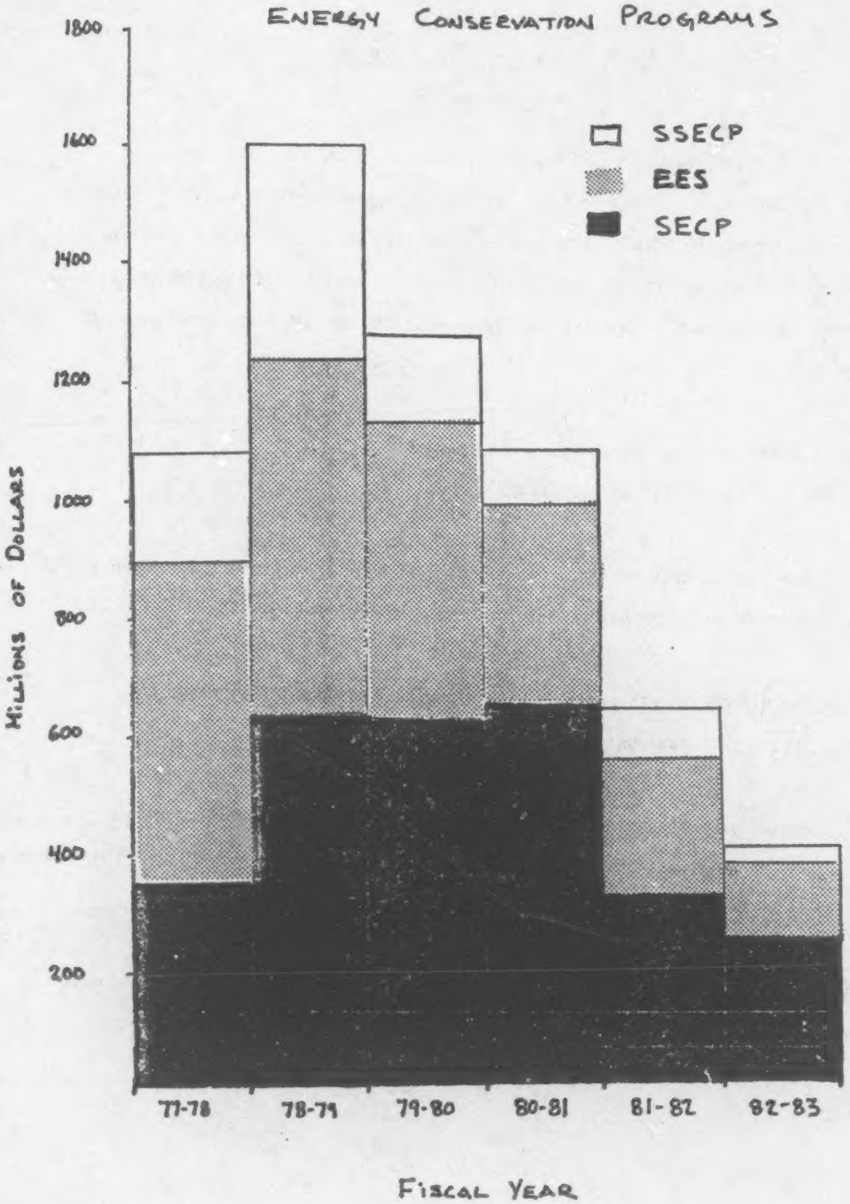
CONSERVATION MEASURES IMPLEMENTED
BY CONNECTICUT RESIDENTS

SOURCE: NOVEMBER 1982
CONNPOLL ENERGY SURVEY



Appendix IV

FUNDING FOR CONNECTICUT ENERGY CONSERVATION PROGRAMS



APPENDIX V

Case History

Nap Brothers Parlor Frame Company

Glastonbury, CT

Al Napolitano, owner of Nap Brothers Frame Company in Glastonbury, was looking for ways to save money and requested an energy audit in 1978. Neal Crowley, Program Manager of the Small Business Energy Service, conducted the audit with Mr. Napolitano and made several recommendations to reduce heating and lighting costs. Mr. Napolitano implemented most of the recommendations and has been impressed with the results.

Windows were weatherstripped and blocked with insulation at a cost of $680. The first year savings were $630.

One hundred watt incandescent lighting fixtures were converted to twenty watt fluorescent fixtures at a cost of $570. First year savings: $2,698.

The old boiler was replaced with a new dual oil-gas boiler which cost $25,000. First year savings: $6,000.

Heated exhaust air was redirected back into the factory during the winter. Cost $3,000. Annual savings $3,670.

Three years later, the capital costs have been paid for by the savings from electricity and fuel bills. Nap Brothers has saved about $13,000 per year and will continue to save at increasing rates as fuel costs rise.

Mr. Napolitano is pleased. If it hadn't been for the energy audit, "we probably would have gone out of business," he said.

Mr. Napolitano also said he preferred having an audit conducted by the Small Business Energy Service because they aren't trying to sell anything. "I knew I could get an unbiased answer from Neal," he said.

A BRIEF INTRODUCTORY BIOGRAPHY
of
BRADFORD S. CHASE

Acting Under Secretary for Energy
Office of Policy and Management

Energy Division

Undergraduate Degree - Landscape Architecture

Graduate Degree - Urban Planning

Worked in the field of City, Regional and State Planning in the states of Massachusetts, Michigan, Pennsylvania and Connecticut.

Joined Connecticut State Service in 1962 and has been involved in a broad range of planning and administrative activities at the state, regional and town levels.

Became directly involved in energy matters in 1975 with the formation of the State Department of Planning and Energy Policy.

Been primarily involved in Energy Conservation Programs such as Project Conserve and Retrotech, State Agency Energy Management, Outreach to Commercial and Industrial firms, Municipalities and Churches, Schools, Hospitals, Local Government Units and Public Care Institutions.

Established and directed the State Energy Extension Service Energy Conservation Outreach Program. The past 2 years he has been primarily responsible for the overall administration of energy programs in the State Energy Agency.

He was appointed Acting Under Secretary for the State of Connecticut's Energy Division on August 18, 1981.

He is married, has four children, and has lived in Enfield, Connecticut since 1962.

jeg

Mr. SENSENBRENNER. Thank you, Mr. Chase.

Our final witness on this panel will be Mr. Craig Marks.

Mr. Marks.

STATEMENT OF CRAIG MARKS, EXECUTIVE DIRECTOR, ENVIRONMENTAL ACTIVITIES STAFF, GENERAL MOTORS TECHNICAL CENTER, WARREN, MICH.

Mr. MARKS. Mr. Chairman, my name is Craig Marks, I am executive director of General Motors environment activities staff, and I am glad to have this opportunity to share with you my views on one of the research programs sponsored by the Department of Energy.

I have been involved in, or directing or overseeing the progress of automobile engine research and development continually during my 26 years at General Motors. One of my special interests is engine combustion processes, and therefore, I was pleased to be asked to serve on a panel of experts to review the combustion technology research progam at the Sandia National Laboratories, operated under contract to the Department of Energy. On the basis of a recent, intensive, 2-day, on-site, review of this program, I do feel qualified to give you an assessment of its potential value and its significance from the standpoint of an automobile engineer.

First, I should say that General Motors has consistently recommended that Government involvement in such research should be limited to the support of basic as opposed to applied research. Applied research, leading to the development of commercial products to meet market demands, is probably best left in the hands of private industry. I believe that, especially in times of critical financial concern such as these, it is vital that whatever funds are available be allocated to well conceived and properly executed basic research programs. The Sandia National Laboratories Engine Combustion Technology Program is an excellent example of such a program.

Let me briefly outline some important aspects of this program. Its objective is to improve our fundamental understanding of the combustion processes in reciprocating internal combustion engines, the kind of engines which burn practically all of the gasoline and diesel fuel produced in the world today. These processes are extremely complex, each event occurring in a few milliseconds, and repeated up to 400 times per second for a typical engine. Scores of chemical species are involved in hundreds of chemical reactions, and these events are critically dependent upon the transient fluid flow and heat transfer processes which accompany them. It is no wonder that this type of combustion, which is so universal in its application, has, so far, defied attempts to analyze it in the detail necessary to predict its behavior.

The Sandia National Laboratories have established a unique facility to study and understand the fundamentals of this type of engine combustion. Their method employs special optical diagnostic techniques, using laser beams, which can make measurements in the flame of an operating engine, and provide information impossible to obtain only a few years ago. The program combines this experimental capability with extremely powerful computer modeling techniques, the complexity of which challenges the capability of even our most sophisticated modern computers. The Sandia program has assembled a team of very competent analysts and experimenters and has developed, in cooperation with industry, a basic research program which is focused on relevant engine problems.

Now, even if you accept my judgment that this is a high-quality research effort directed toward resolving some important engine combustion issues, I realize that the question still remains, "What justifies the expenditure of public moneys on this effort at this time?" Although I cannot speak to the alternatives which may be competing for funds, I believe the following five points should be considered in judging the value to society of this particular research program:

First, if successful, the program could speed the achievement of some longstanding and well recognized goals which could increase engine efficiency by at least 10 percent. If such an improvement were applied to only one-tenth of the gasoline which we consume, then, each and every day, the savings to the Nation would be more than the annual funding for this program.

Second, this program provides some much-needed support for university research, which makes an important educational contribution, in addition to whatever direct benefits result. Our Nation's critical need for more well-trained engineering graduates is well documented, as is the need for support to provide the faculty required to train these engineers.

Third, the program makes available a public research facility with sophisticated combustion diagnostic tools. I believe that the new knowledge produced, together with the availability of this facility to independent researchers, increases the likelihood that an individual innovator will be able to come up with a true engine breakthrough, which could be of immeasurable significance.

Fourth, this fundamental combustion research also has the potential for spinoff applications capable of increasing the efficiency of other combustion systems, which do not involve engines, but do account for about three-fourths of our Nation's energy consumption.

Last, successful achievement of the goals of this research would make a significant contribution toward improving the international competitive position of our country in this field.

Finally, I should comment on the role of industry in sponsoring such research. Certainly engine combustion is an area of vital interest to the automobile industry and, over the years, General Motors has performed and published the results of a great deal of pioneering engine combustion research. Indeed, today, some of our research scientists and engineers are using many of the same experimental techniques and computer modeling approaches that are being employed in the Sandia program. We are applying the techniques and the results developed in the Sandia program to our own research and development activities, right now. The Sandia, university, and industry combustion programs complement one another and speed progress just as the completion of a jigsaw puzzle is aided by the cooperation of several people. The Sandia facility and personnel form a large part of the total effort in this area, providing a sort of critical mass, which I think is needed to maintain steady progress on this difficult job of understanding the combustion process in reciprocating engines.

I recognize that prudent fiscal management requires every budget item to receive critical scrutiny, and the Energy Conversion and Utilization Technologies activity should be no exception. Perhaps other portions of this program are less well justified—I am not familiar with them—but I am confident that the substantial potential rewards and the demonstrated merits of the sandia national laboratories engine combustion technology program make it a strong candidate for continued support.

Thank you.

[The prepared statement of Mr. Marks follows:]

TESTIMONY BEFORE THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
U.S. HOUSE OF REPRESENTATIVES
MARCH 10, 1983

Mr. Chairman, and Members of the Committee, my name is Craig Marks. I am the Executive Director of General Motors Environmental Activities Staff, and I am glad to have this opportunity to share with you my views on one of the research programs sponsored by the Department of Energy.

I have been involved in, or directing, or overseeing the progress of automobile engine research and development continually during my 26 years at General Motors. One of my special interests is engine combustion processes, and, therefore, I was pleased to be asked to serve on a panel of experts to review the combustion technology research program at the Sandia National Laboratories, operated under contract to the Department of Energy. On the basis of a recent, intensive, two-day, on-site, review of this program, I feel qualified to give you an assessment of its potential value and its significance from the standpoint of an automobile engineer.

First, I should say that I am in total agreement with the testimony given to this Committee last July by John Caplan, Executive Director of General Motors Research Laboratories, regarding the appropriate role of the government in automotive research. General Motors has consistently recommended that government involvement in such research should be limited to the support of basic as opposed to applied research. Applied research, leading to the development of commercial products to meet market demands, is best left in the hands of private industry. I believe that, especially in times of critical financial concern such as these, it is vital that whatever funds are available be allocated to well conceived and properly executed basic research programs. The Sandia National Laboratories Engine Combustion Technology Program is an excellent example of such a program.

Let me briefly outline some important aspects of this program. Its objective is to improve our fundamental understanding of the combustion processes in reciprocating internal combustion engines, the kind of engines which burn practically all of the gasoline and diesel fuel produced in the world today. These processes are extremely complex, each event occurring in a few milliseconds, and repeated up to 400 times per second for a typical engine. Scores of chemical species are involved in hundreds of chemical reactions, and these events are critically dependent upon the transient fluid flow and heat transfer processes which accompany them. It is no wonder that this type of combustion, so universal in its application, has, so far, defied attempts to analyze it in the detail necessary to predict its behavior.

The Sandia National Laboratories have established a unique facility to study and understand the fundamentals of this type of engine combustion. Their method employs special optical diagnostic techniques, using laser beams, which can make measurements in the flame of an operating engine, and provide information impossible to obtain only a few years ago. The program combines this experimental capability with extremely powerful computer modeling techniques, the complexity of which challenges the capability of even our most sophisticated modern computers. The Sandia program has assembled a team of very competent analysts and experimenters and has developed, in cooperation with industry, a basic research program which is focused on relevant engine problems.

Now, even if you accept my judgment that this is a high-quality research effort directed toward resolving some important engine combustion issues, I realize that the question still remains, "What justifies the expenditure of public monies on this effort at this time" Although I cannot speak to the alternatives which may be competing for funds, I believe the following five points should be considered in judging the value to society of this research program:

First, if successful, the program could speed the achievement of some long-standing goals which could increase engine efficiency by at least 10%. If such an improvement were applied to only one-tenth of the gasoline which we consume, then, each and every day, the savings to the nation would be more than the annual funding for this program.

Second, this program provides some much needed support for university research, which makes an important educational contribution, in addition to whatever direct benefits result. Our nation's critical need for more well-trained engineering graduates is well documented, as is the need for support to provide the faculty required to train these engineers.

Third, the program makes available a public research facility with sophisticated combustion diagnostic tools. I believe that the new knowledge produced, together with the availability of this facility to independent researchers, increases the likelihood that an individual innovator will be able to come up with a true engine breakthrough, which could be of immeasurable significance.

Fourth, this fundamental combustion research also has the potential for spin-off applications capable of

> increasing the efficiency of other combustion systems, which do not involve engines, but do account for about three-fourths of our nation's energy consumption.
>
> Lastly, successful achievement of the goals of this research would make a significant contribution toward improving the international competitive position of our country.

Finally, I should comment on the role of industry in sponsoring such research. Certainly engine combustion is an area of vital interest to the automotive industry and, over the years, General Motors has performed and published the results of a great deal of pioneering engine combustion research. Indeed, today, some of our research scientists and engineers are using many of the same experimental techniques and computer modeling approaches being employed in the Sandia program. We are applying the techniques and the results developed in the Sandia program to our own research and development activities, right now. The Sandia, university, and industry combustion programs complement one another and speed progress, just as the completion of a jigsaw puzzle is aided by the cooperation of several people. The Sandia facility and personnel form a large part of the total effort in this area, providing a sort of critical mass, which I think is needed to maintain steady progress on this difficult job of understanding the combustion process in reciprocating engines.

I recognize that prudent fiscal management requires every budget item to receive critical scrutiny, and the Energy Conversion and Utilization Technologies (ECUT) activity should be no exception. Perhaps other portions of this program are less well justified -- I am not as familiar with them -- but I am confident that the substantial potential rewards and the demonstrated merits of the Sandia National Laboratories Engine Combustion Technology Program make it a strong candidate for continued support.

****

Mr. **Sensenbrenner**. Thank you, very much, Mr. Marks.

I have a couple of brief questions for Mr. Chase.

In the previous panel, Mr. Carter complained that many of the energy audit activities that are being conducted under the EES small business programs completed directly with services offered by the private sector engineering firms. What is your reaction to that? And couldn't a private firm, which employs people who pay taxes, do a lot of this work thereby reducing unemployment and easing the load on the Federal budget deficit?

Mr. **Chase**. I think we have to look at that statement in the context of the type of effort Connecticut had—he cited Connecticut specifically—in 5 years we did 2,500 audits in the State of Connecticut. There are 30,000 small businesses to be done. I think there's a big job to be done. I think there's an awful lot of room for everybody to have a role in that. We have had very little problem with competition or with complaints of competition in the State of Connecticut. I would say that the more choice the consumer has or the small business has, the better for him or her in terms of getting the kind of service he or she would like.

Mr. **Sensenbrenner**. Since the price of oil appears to be headed downward and there is no reversal of that trend in sight for the near-term future, I'm wondering what impetus there will be for future conservation efforts since it is going to be cheaper to heat our homes and run our cars, assuming we don't use natural gas.

Mr. **Chase**. We depend 70 percent in Connecticut on oil. This is a very real concern to us. I think it is a short-range perspective that people would say there's no problem. We do have a surplus of oil there today; however, I think the energy problem is larger than today or next week or next year. I think we have to address the problem in a long-term fashion, and I think for us in New England the strategy, since we have no resources of our own, is conservation.

Mr. **Sensenbrenner**. OK. Thank you very much, counsel.

Mr. **Frankel**. I wonder if you can elaborate on some of the findings of the evaluation of the energy related inventors program that was carried out by Oak Ridge?

Mr. **Wilbanks**. The energy-related inventions program, as you know, was started in 1974 as the result of an act of Congress and has been in operation since then. We began an evaluation of this program in September 1981. As of that time, the National Bureau of Standards had received more than 17,000 applications to be evaluated for possible DOE support. Out of these 17,000-some inventions, the National Bureau of Standards had judged that 191 of them were worthy of support and submitted those to DOE for processing.

As of that time 95 of these 191 inventions had been approved for DOE support; for our evaluation we picked 30 of these to look at in some detail. Of these 30 projects, twenty-nine of them actually received DOE support; the 30th was from a small business that was later absorbed by another firm and withdrew its application. Our evaluation showed that 26 of the 29 programs or inventions that received DOE support had, by the time of our evaluation, actually moved to the next step in the R&D sequence, which was the objective of the program. Twenty-seven of the technologies had been patented. Nearly half of the Twenty-nine technologies had received private sector support as well as the public sector support. We think this was largely because of the kind of validation that the NBS stamp of approval gave to them. Six of the twenty-nine had been commercialized, which far exceeded the expectations of many of the people who supported the program in the beginning. So it seems clear that the program did an effective job both in generating suggestions of inventions from inventors and in achieving the objectives that were set out for it.

The question that I think was raised by an ERAB report, submitted recently, is whether or not this program is duplicated by other Federal programs such as the Small Business Development Act of 1982. I'm really not in a position to comment on that other than to say that somewhere in the vast array of programs, it appears to us—on the basis of our evaluation—that there should be support for these kinds of energy-related inventions.

Mr. **Frankel**. You talk about the need for better data and analyses. Can you tell us a little bit about what has happened to the capabilities of Oak Ridge in that area? Especially the group that Eric Hirst has worked with.

Mr. **Wilbanks**. There are two areas of data analyses that have been an important part of the Oak Ridge programs over the years. One is analyses of the causes—the determinants of energy use. This work goes back to 1969. The other is evaluations of conservation programs.

Support for the analyses of the determinants of energy use has shrunk considerably; in fact, it has largely disappeared. That's not just true for Oak Ridge programs of this sort, but also for programs at Lawrence Berkeley Laboratories, Princeton, and elsewhere.

The reason is not so much, I think, because decisions were made that this kind of work is unnecessary but that the agencies that supported it had their overall budgets cut.

Mr. **Frankel**. Mr. Chase, what level of funding do you need to do a good job with your energy extension service program in Connecticut and what would that imply on the national level?

Mr. **Chase**. I would say it would be the level of funding we had 3 years ago.

Mr. **Frankel**. Has the State of Connecticut been able to pick up any of the funding for the energy extension service that has been cut by DOE?

Mr. **Chase**. We have since the beginning.

Mr. **Frankel**. A 50–50 split or what?

Mr. **Chase**. No. I would say probably at the height it was 70 percent Federal and 30 percent State. There has been State funding in that program since before 1977, since before the program started.

Mr. **Frankel**. And what is it now?

Mr. **Chase**. In terms of ratio it is probably 50–50. I would say in the $15 million range for EES.

Mr. **Frankel**. Thank you very much.

Mr. **Sensenbrenner**. Thank you very much, gentlemen. I have to apologize about the low attendance today. There are some Democratic goings on and that's why this is one of the rare hearings on this side of the Capitol that you will see presided over by a Republican Member of the House.

Thank you very much for your patience and for your excellent testimony. The hearing is adjourned subject to the call of the Chair.

[Whereupon, the hearing was adjourned at 11:02 a.m.]

1984 DEPARTMENT OF ENERGY AUTHORIZATION

TUESDAY, MARCH 15, 1983

House of Representatives,
Committee on Science and Technology,
Subcommittee on Energy Development and Applications,
Washington, D.C.

The subcommittee met, pursuant to recess, at 2:04 p.m., in room 2318, Rayburn House Office Building, Hon. Don Fuqua (chairman of the subcommittee) presiding.

Present: Representatives Fuqua, Simon, Sensenbrenner, Schneider, Bateman, Lewis, and Gregg.

Staff present: Donald Teague, Daniel Steinway, minority counsel, and John Ratzel, minority counsel.

Mr. Fuqua. The subcommittee will be in order.

Without objection, permission to record or photograph will be granted.

We conclude our hearings with outside witnesses on the DOE conservation and renewable energy programs.

The ERAB solar R&D report stated that "rapid changes in Federal policy have been disruptive to orderly progress," in solar R&D. Yet, again we find that the DOE authorization request would cut more than 60 percent from the solar budget.

Many of the projects that are being affected were long-term, high-risk, high-payoff projects when they were started in the mid-1970's. All need just a few more years to become mature enough for the private sector to take over commercialization.

During the course of these hearings, we will explore, from the outside witnesses, whether we should try to continue these projects or follow through with the request that is contained in the budget.

At this time, I would like to recognize Mr. Sensenbrenner for any comments that he might wish to make.

Mr. Sensenbrenner. Thank you, Mr. Chairman, for this opportunity to extend a welcome to our distinguished panel members. We look forward to their testimony on the renewable energy programs conducted by the Department of Energy.

The administration has proposed significant reductions in these programs for fiscal year 1984. These reductions are premised upon the administration's commitment to fund only those research programs that may be termed high-risk, long-term activities that the private sector is unable to fund.

As representatives of corporations and research organizations that have been involved in the development of renewable energy, your thoughts concerning the underlying premise of the administration's proposals and the impact the prior programs have had upon our economy and our energy supply will be appreciated and useful in determining the appropriate level of funding for these programs.

I look forward to your testimony on this issue.

Mr. **Fuqua**. Thank you, Mr. Sensenbrenner.

We will first begin with Dr. Lawrence Papay, with Southern California Edison; followed by Mr. Byron Washom, with the Avanco Corp.; and then Mr. Bobby Tharpe, with General Electric; and Arthur Jackson with Hamilton Standard Corp.

Dr. Papay, we are happy to have you here today. How is "Solar One" going?

Mr. **Papay**. You are giving away half of my talk.

Mr. **Fuqua**. Oh, all right.

Please proceed.

STATEMENT OF DR. LAWRENCE PAPAY, VICE PRESIDENT, SOUTHERN CALIFORNIA EDISON CO.

Dr. **Papay**. Thank you, Mr. Chairman and members of the subcommittee. It is a great pleasure for me to be here to talk about solar and wind technologies. I will use the word "solar" in a generic sense to include the various solar technologies and wind.

My responsibilities with Southern California Edison include the implementation of strategies, plans, and actions to accelerate the development and commercialization of various emerging solar energy technologies.

We appreciate the opportunity to discuss the important role of continued Federal involvement to foster cost-effective solar research and bring solar technologies to the point where the private sector can maintain momentum in commercializing these activities.

We are in full agreement that the involvement of the Federal Government in solar should have emphasis on long-term, high-risk, potentially high-payoff R&D for which market incentives are not sufficient. However, it is also important for DOE to complete its ongoing demonstration projects so as to obtain maximum benefits on its prior investments.

Let me go to the solar thermal portion of the DOE budget first and talk about central receivers within solar thermal systems.

The 10-megawatt Solar One pilot plant is a major DOE accomplishment toward the objectives of bringing this promising technology closer to commercial reality. Major milestones researched in 1982 include: The first generation of electricity into the Southern California Edison grid in April 1982; gross production of 11.4 megawatts with a net production of 10.4 megawatts from solar-generated steam; operation of the thermal storage system at 8.2 megawatts gross and 7.3 megawatts net. I should point out that the design level is 7 megawatts. This system has generated electricity for 12 hours during the nighttime hours.

We have already learned a great deal from Solar One, but much remains to be done. The pace at which testing and operating objectives for Solar One can and will be met is directly related to the level of funding.

The timing of prospective follow-on central receiver projects will also be influenced by the level of funding for Solar One.

The current DOE budget request for Solar One in fiscal year 1984 is not sufficient to carry out the scheduled tests. We estimate that DOE will need about $3.7 million in fiscal year 1984 for the operation and maintenance of Solar One, and an additional $1.3 million will be required for Sandia Laboratories to evaluate the data gathered.

We strongly urge the subcommittee to increase the DOE's Solar One budget authorization from the requested $4 million to a more realistic level of $5 million.

We also feel that authorization for the component development program should be increased. This program must have adequate funds to continue the necessary plant automation and control system development for central receiver technology which should be tested at Solar One.

These component development works will be performed by DOE subcontractors at an estimated cost of $4.2 million in fiscal year 1984.

Early results of Solar One were so favorable that SCE issued a program opportunity announcement for solar energy in May 1982 for the development of one or more next-generation solar thermal central receiver powerplants, so-called Solar 100.

As a result of this announcement, discussions are being held with four companies at present. Financing of this project by the private sector can only occur if the following actions by the Federal Government are carried out: First, Solar One testing must be carried through as scheduled. This can be accomplished by the previous recommendation.

Second, the private sector needs additional information on the technical feasibility and operational characteristics of molten nitrate salt. So adequate funding and completion of the molten salt experiment at the Central Receiver Test Facility will provide this information.

Finally, extension of energy tax credits through 1990 are a must.

As to the current solar thermal repowering program, we feel that DOE should be funded in fiscal year 1984 to carry at least one repowering project through final design.

In regard to solar dishes within the solar thermal program, we point out in the testimony that the dish technology is still in the development and demonstration phase, but its modularity and high efficiency make it a leading candidate for commercial success. Without continued leveraging by DOE funding, the development of this technology and the expected cost reduction will be delayed.

We recommend continued funding of the dish program at a $12 million to $13 million per year level, which is a typographical error in my prepared remarks. This will allow DOE to complete the design and testing of competitive dish concepts through the prototype phase.

Given the above recommendations, we feel that DOE must be funded in fiscal year 1984 for the solar thermal program at a budget level of approximately $53 million.

In regard to photovoltaic systems, the biggest problem facing the private sector is the commercialization of current photovoltaic technology, with the high front-end costs associated with manufacture and installation. We agree with the DOE recommendation for reduced Federal involvement in the demonstration and validation of current photovoltaic technologies. Priority of the DOE photovoltaic research program should be placed on the development of advanced cells which offer high efficiency, reliability, and long-term stability, such as thin films, multilayer, and single crystal cells.

The next priority should be to develop a cost effective automated cell production methodology.

Thus, the following recommendations are offered for your consideration: Reinstate funding for high-purity, low-cost silicon material research and advanced silicon sheet research; reduce funding for theory and analysis, polycrystalline material research, and duplicative efforts in analytic models and reliability studies.

Limit system testing activities and balance of system development to advanced materials only.

Increase efforts for the commercialization of second-generation technologies which have high potential.

In regard to wind energy systems, our assessment here is that the technology for small wind energy systems is approaching full commercialization; thus, it is appropriate for DOE to phase out activities in this area.

Large wind turbine technology, however, is still in the phase where risks are substantial, and it is not ready to totally be picked up by the private sector.

The following programs are of particular importance and should be funded and performed during fiscal year 1984: In terms of the NASA research and testing, the experimental MOD-0 at Plum Brook is the only suitable testing facility in the world for the evaluation of new designs for wind turbine components.

NASA's research and testing activities have provided substantial data to the private sector for design improvements of wind turbines, and we recommend continued support.

In regard to vertical axis systems research, the vertical axis wind turbine offers a high potential for reduced system cost and increased reliability. Sandia Laboratory is currently the only major U.S. research center conducting vertical axis system research. We recommend continued support in this area.

Development of the MOD-5 offers an opportunity to reduce costs by as much as 50 percent over current design. We urge restoration of the DOE budget for the development and demonstration of the MOD-5 concept on a cost-sharing basis with private developers.

The MOD-2 demonstration units at Bonneville have yielded data on design and operation of large turbines. Continued funding to operate, repair or modify machines and collect data is required.

In summary, we recommend that the fiscal year 1984 wind program budget be increased to a $16 million to $18 million level.

A word on energy tax credits. In the extensive negotiations we have carried out for the installation of various solar and wind generation facilities, a number of third parties have stated explicitly that tax credit and accelerated depreciation have been key factors in determining the economic feasibility of specific projects. If these tax incentives were not available, most of those new facilities under consideration and negotiation would not be built.

We recognize that this subcommittee is not the committee of jurisdiction for amendments to the Internal Revenue Code. However, because of your interest in the development of renewable and alternate energy resources, we offer the following suggestions for making these tax incentives more effective in spurring such development:

First, extension of the credits at least through 1990 to cover the initial commercialization phase of these emerging technologies as per H.R. 1775; second, the energy tax credits and accelerated depreciation can be made more effective by making these incentives available to utility companies. This may sound self-serving to some extent, but our experience shows that selected projects will only proceed with our involvement. However, our involvement without tax incentives being available impacts project economics unfavorably.

In closing, I appreciate the opportunity to present these views on such an important subject. Our analyses and recommendations are based on our extensive background and involvement in the technologies, as well as our continued interaction with entrepreneurs, manufacturers, and research entities.

Again, thank you for the opportunity to present these views. I would be happy to answer any questions you may have.

[The prepared statement of Dr. Papay follows:]

Prepared Testimony

of

DR. LAWRENCE T. PAPAY
Vice President
Southern California Edison Company

CONCERNING THE DEPARTMENT OF ENERGY FY 1984 BUDGET REQUEST FOR SOLAR ENERGY PROGRAMS

Before the
Subcommittee on Energy Development and Applications

of the

Committee on Science and Technology

of the

United States House of Representatives
Washington, D.C.

March 15, 1983

I. INTRODUCTION

Mr. Chairman, members of the Subcommittee, it is a great pleasure for the Southern California Edison Company and myself to present our views on such an important topic - solar and wind energy research, development, and commercialization.

My name is Lawrence T. Papay, Vice President of the Southern California Edison Company. My responsibilities with my Company include the implementation of strategies, plans and actions to accelerate the development and commercialization of various emerging solar energy and other technologies.

Southern California Edison Company (SCE) is committed to the accelerated development and deployment of renewable and alternative energy resources. Members of this Subcommittee are familiar with one of our major pilot projects, the 10 Megawatt (MW) Solar One facility, near Barstow, California, which is now operational. As a result of our work with the Subcommittee in connection with Solar One, we are aware of your strong continuing interest in the development of renewable and alternative energy resources. We appreciate this opportunity to discuss the important role of continued federal involvement to foster cost-effective solar research and bring solar technologies to a point where the private sector can maintain momentum in commercialization activities.

Based on the technology forcing role SCE has played in the research, development and demonstration of solar energy technologies, we have identified several areas where the private sector needs help so that your constituents, our consumers, can enjoy the benefits of solar energy at the earliest possible time.

II. THE FEDERAL ROLE IN SOLAR RESEARCH

We are in full agreement with the Subcommittee that the involvement of the federal government in solar technologies should emphasize long-term, high-risk, potentially high payoff solar R&D for which market incentives are not sufficient. It is also important for DOE to complete its on-going demonstration projects so as to obtain maximum benefits on its prior investments. The recently published report "Solar Energy Research and Development: Federal and Private Sector Roles," by the Solar R&D Panel of the Energy Research Advisory Board (ERAB) to the U.S. Department of Energy (DOE) is also consistent with this position. The Panel, on which I was a member, found that solar technologies have progressed significantly in the past 10 years and represent a group of highly promising energy options for the United States. DOE has been one of the primary driving forces in bringing these technologies forward. It also found, however, that decreases in federal funding will result in a slowdown or termination of some technologies. Other major findings of the ERAB report underscore the need for a continued federal presence during these early stages of development. These findings include the important federal role that its research provides information and knowledge which benefit the country as a whole--research which is often not of sufficient benefit to any one interest to warrant private investment. Further, continuity in federal actions is essential to solar energy R&D and expectation of such continuity helps define the context essential to private sector investment decisions.

There exists, however, a gap between the completion of the R&D phase and the commercialization phase. We feel that the federal government must ensure that, at the completion of the R&D phase, a smooth transition to the private sector commercialization be provided. This is where the federal government can provide valuable assistance to industry--by making available certain tax incentives, such as the energy tax credit and accelerated depreciation, so that the private sector can proceed. Without these tax incentives, the federal government would not be able to maximize the potential return on its prior research expenditures and the commercial availability of solar technologies would be greatly delayed.

We would like to offer the following specifics concerning the DOE FY 1984 budget request for the Subcommittee's consideration. Adoption of these recommendations will enhance the effectiveness of the DOE solar research effort.

III. SOLAR THERMAL SYSTEMS

1. Solar Central Receiver

In conjunction with the utility consortium (Southern California Edison Company and the Los Angeles Department of Water and Power), the 10 MW Solar One Pilot Plant is a major DOE accomplishment toward the objectives of bringing this promising technology closer to commercial reality. In particular, major milestones reached in 1982 include:

a. First generation of electricity to the Southern California Edison grid was achieved in April 1982, with over 1.6 million kWh produced to date.

b. Gross production of 11.4 MW of electricity was achieved with a net generation of 10.4 MW from solar generated steam.

c. The thermal storage system was put into operation, generating 8.2 MW gross and 7.3 MW net from stored steam. This system has generated electricity up to 12 hours at night.

We have already learned a great deal from Solar One, but much remains to be done if Solar One is to set the stage for future commercial central receiver solar facilities. Continued testing and operation of this facility is required. In this respect, the following tests scheduled for FY 1984 would provide vital design, operational and economic data:

a. Optimization of plant operation and reduction of operating personnel by developing and implementing clear-day and cloudy-day automatic operation scenarios.

b. Determination of plant operating characteristics through engineering tests.

c. Performance testing of the plant under various modes of operation and under differing conditions and constraints.

With adequate funding, these tests could be conducted in FY 1984 and would conclude the initial testing period of Solar One, leaving only the operating period to be funded. The pace at which testing and operating objectives for Solar One can and will be met is directly related to the level of funding. The timing of prospective follow-on central receiver projects will also be influenced by the level of funding for Solar One.

The current DOE budget request for Solar One in FY 1984 is not sufficient to carry out the above tasks. We estimate that DOE will need about $3.7 million in FY 1984 for the operation and maintenance of Solar One. An additional $1.3 million will be required for Sandia to evaluate the data gathered. Even at this $5 million level of funding for Solar One operation and maintenance (O&M), no contingency is provided for unexpected repairs. We strongly urge the Subcommittee to increase the DOE's Solar One budget authorization from the requested $4 million to a more realistic level of $5 million.

We also feel that authorization for the component development program should be increased. In particular, this program must have adequate funds to continue the necessary plant automation and control system development for the central receiver technology which should be tested at Solar One. These component development works will be performed by DOE subcontractors at an estimated cost of $4.2 million for FY 1984. Minimal subsequent year funding will be required to complete the effort. Implementation of these control and automation concepts and testing at Solar One is essential and will provide timely and useful data for the private sector. We recommend increased funding for the component development program to accomplish the above activities in FY 1984.

Solar One is just now beginning to produce the kind of data which will allow the private sector to invest in central receiver technology on a commercial scale. We consider Solar One to be of major importance for the DOE solar thermal research and development activities. Continued and adequate funding for Solar One is essential at this time. Thus, we encourage efforts of this Subcommittee to place Solar One high on the priority list for DOE funds. If a shortage of funds exists to adequately cover Solar One and the component development program, we would prefer to see funds shifted from less developed solar technologies consistent with the recently completed Energy Research Advisory Board's Solar Panel Report.

Early results of Solar One were so favorable that SCE issued a Solar Program Opportunity Announcement in May 1982 for the development of one or more next-generation Solar Thermal Central Receiver power plants (Solar 100). Four companies have expressed interest in constructing a Solar Thermal Central Receiver facility in the 50-100 MW size range. Discussions with these four companies are underway. Financing of this project by the private sector can only occur if the following actions by the federal government are carried out:

a. The Solar One testing program must be carried through as scheduled. The private sector needs the design, operational, and economic data obtainable only through the Solar One testing program. This can be accomplished by the previously recommended FY 1984 DOE budget level for Solar One and for the component development program.

b. The private sector needs additional information on the technical feasibility and operational characteristics of molten nitrate salt solar thermal receiver electric power generation technology. Adequate funding and completion of the Molten Salt Electric Experiment by the DOE at the Central Receiver Test Facility (CRTF) will provide such needed information and would assist the private sector with development of an alternative competitive design.

c. With the scheduled expiration of the federal energy tax credit in 1985, investors are hesitant to make financial commitments to solar technologies. This problem is of particular importance for the Solar 100 project, due to high front-end costs and a long construction period. In order to proceed, investors will require assurance that the current tax credit and accelerated depreciation will be available when the facility goes into operation. This can be accomplished by the extension of the energy tax credit through 1990.

As to the current solar thermal repowering program, we feel that the DOE should be funded in FY 1984 to carry at least one repowering project through final design. This, together with the planned component development program, would enable the private sector to commercialize the technology.

2. Solar Trough

The solar trough technology is near commercialization and is being picked up by the private sector. No further DOE involvement, other than dissemination of information for smooth technology transfer, is required.

3. Solar Dish

While the solar dish technology is still in the development and demonstration phase, its modularity and high efficiency makes it a leading candidate for commercial success. Private companies have committed substantial funding during the last three years; however, without continued leveraging by DOE funding, the development of this technology and the expected cost reduction will be delayed for at least one year and, more likely, several years.

We recommend continued funding of the dish program at a $12-13 million level for the program completion and urge this Subcommittee to reject the total elimination of funding as proposed in the FY 1984 DOE budget request. This will allow the DOE to complete the design and testing of competitive dish concepts through the prototype phase. In particular, both the Stirling engine and the Brayton cycle engine need to be tested and evaluated.

Given the above necessary activities that must be performed during FY 1984, the DOE Solar Thermal Program budget should be increased to about $53 million.

IV. PHOTOVOLTAIC SYSTEMS

The biggest problem facing the private sector in the commercialization of current photovoltaic technology is the high front end cost associated with the manufacturing and installation of photovoltaic cells. Manufacturers are reluctant to make investments in production facilities in light of rapid obsolescence and uncertainties in market development. On the other hand, if our nation were to wait for the next generation of technology, such as single cell and thin film technologies, commercialization of photovoltaic technology would be delayed at least 10 years.

Even though we agree with the current federal philosophy in conducting long-term high risk research in photovoltaics, there is a major gap existing in the commercialization activities which cannot be picked up by the private sector. Thus, we feel that the current FY 1984 budget request can be redirected to near-term technologies.

We agree with the DOE's recommendation for reduced federal involvement with the demonstration and validation of current photovoltaic technologies. Priority of the DOE photovoltaic research program should be placed on development of advanced photovoltaic cells which offer high efficiency (greater than 15 percent), longevity and long-term stability. These technologies include thin film, multi-layer and single crystal cells. The next priority should be to develop a cost effective automated cell production methodology.

Thus, to further increase the effectiveness of the DOE photovoltaic program, the following recommendations are offered for the Subcommittee's consideration:

a. Reinstate funding for:
   - high purity, low cost silicon material research,
   - advanced silicon sheet (ribbon technology) research;

b. Reduce funding for:
   - all theory and analysis,
   - polycrystalline material research,
   - duplicative efforts in analytic models and reliability studies;

c. Limit system testing activities and balance of system development to advanced material only; and,

d. Increase effort for the commercialization of second generation photovoltaic technologies with high potential for rapid cost reduction and automated production.

With the above recommended shift in priorities, the DOE will only require a slight in its FY 1984 budget request. Since the exact amount of such increase is subject to the evaluation of existing DOE obligations with subcontractors and national laboratories, no recommended budget level is made.

V. WIND ENERGY SYSTEMS

Based on our assessment, technology for small wind energy systems is approaching full commercialization. Thus, it is appropriate for DOE to phase out its activities in this area.

Large wind turbine technology, however, is still in the phase where risks are substantial and it is not ready to be picked up by the private sector. While we feel that most of the DOE activities in large wind turbines are appropriate, the following programs are of particular importance and should be funded and performed during FY 1984:

1. National Aeronautics and Space Administration (NASA) Research and Testing

The experimental NASA MOD-0 turbine at Plum Brook, Ohio, is the only suitable testing facility in the world for the evaluation of new designs for such wind turbine components as blades, generators and control systems. Accomplishments of NASA's research and testing activities have provided substantial data to the private sector for design improvements of wind turbines. These activities, while very cost effective on a national level, are not likely to be picked up by the small-scale to medium-scale wind turbine manufacturers. As a result, the cost reductions and reliability improvements required to make wind turbines competitive will be substantially delayed.

2. Vertical Axis System Research

The vertical axis wind turbine system offers a high potential for reduced system cost and increased reliability. In concept, its design would allow use of wind regimes which are marginal for the more conventional horizontal axis wind turbines. Sandia Laboratory, under contract with DOE, is currently the only major U.S. research center or manufacturer conducting vertical axis system research. Unresolved issues relating to this technology, such as scale-up capability, efficiency improvement, blade design and aerodynamic performance, must be answered prior to commercialization.

3. Development of MOD-5

The MOD-5 wind turbine offers an opportunity to reduce the cost of energy from a large wind turbine by as much as 50 percent over the current design. Preliminary conceptual design for the MOD-5 has been completed. In light of the reported operational difficulties facing the current design and the high potential benefits of MOD-5, we urge the restoration of the DOE budget for the development and demonstration of the MOD-5 concept on a cost-sharing basis with private developers.

4. MOD-2 Demonstrations

The MOD-2 demonstration units at the Bonneville Power Administration have yielded substantial data on design and operation of large wind turbines. Continued funding to operate, repair or modify the machines and collect data are required so as to maximize benefits from prior federal expenditures.

Based on the above discussion, the current DOE budget request of $8.6 million would not be adequate to cover the required activities. Thus, we recommend that the FY 1984 Wind Program budget be increased to a $16 to $18 million level.

VI. IMPORTANCE OF THE FEDERAL ENERGY TAX CREDIT

In our extensive negotiations for the installation of various solar and wind generation facilities, a number of third parties have stated explicitly that tax credit and accelerated depreciation have been key factors in determining the economic feasibility of specific projects. The energy tax credit, together with accelerated depreciation, has definitely provided an effective and key economic incentive to entrepreneurs to move forward with the commercialization of various solar and wind technologies. If these tax incentives were not available, most of those new facilities under consideration and negotiation would not be built.

In passing the Crude Oil Windfall Profit Tax Act of 1980, Congress enacted the energy tax credit to encourage investment in emerging technologies, to accelerate their subsequent commercialization, and to reduce our nation's heavy dependence on foreign oil.

Congress recognizes that the energy tax credit is necessary to the deployment of these emerging technologies and to the national interest. In response to this Congressional commitment, the private sector has mobilized its resources and has developed a substantial momentum toward this important national goal. The private sector is receiving mixed signals due to uncertainties facing the future of the energy tax credit. If the private sector momentum is to be maintained, continued Congressional commitment to both the development of renewable energy resources and the continuation of the tax incentives is essential.

Southern California Edison Company recognizes that this Subcommittee is not the committee of jurisdiction for amendments to the Internal Revenue Code. Because of your interest in the development of renewable and alternative energy resources, however, we offer the following suggestions for making these tax incentives more effective in spurring such development.

The purpose of the federal tax credit and accelerated depreciation is to make renewable and alternative energy technologies more cost-competitive when compared to conventional, proven technologies and to provide assistance in overcoming the hurdles of accelerated development. Thus, they should be made available, at least through 1990, to cover the initial commercialization phase of these emerging technologies. In particular, HR 1775, introduced by Chairman Fuqua and Representative Lujan, for the extension of the energy tax credit to 1990 deserves your full support.

The energy tax credit and accelerated depreciation can be made more effective by making these incentives available to utility companies. The electric utility industry provides the largest market for renewable energy resources, and constitutes a primary driving force for early commercialization. Our experience shows that selected projects will only proceed with our involvement. However, our involvement without tax incentives being available impacts project economics unfavorably. Making the energy tax credit and accelerated depreciation available to utilities would enable the private sector to proceed with the commercialization of these technologies in the broadest manner possible.

VII. CONCLUSION

Southern California Edison Company appreciates this opportunity to present its views on such an important subject. As a leader in the industry in the development of solar energy technologies, we will continue to devote our corporate resources to their accelerated deployment. Our analysis and recommendations are based on our extensive background and involvement in the technologies, as well as our continued interaction with entrepreneurs, manufacturers and research entities.

Again, thank you for the opportunity to present our views to the Subcommittee. I would be happy to answer any questions you may have regarding my testimony or other matters involving our Company's R&D efforts.

Thank You

BIOGRAPHICAL SKETCH
DR. LAWRENCE T. PAPAY

Dr. Lawrence (Larry) T. Papay, born in New Jersey, earned a Bachelor's Degree in Physics from Fordham University and a Master's and Doctorate in Nuclear Engineering from the Massachusetts Institute of Technology. He is a Registered Professional Nuclear Engineer in California.

Dr. Papay began his career with the Southern California Edison Company in 1970 as the Director of Research and Development, was assigned General Superintendent to manage utility bulk power operations in 1978, and was elected Vice President in January, 1980, at which time he assumed management of the utility's research and development, and quality assurance organizations.

In the past, Dr. Papay has served with the Federal Office of Technology Assessment, Solar Advisory Panel; Federal Power Commission's Technical Advisory Committee on Research and Development; National Science Foundation Solar Energy Panel; chaired the Electric Power Research Institute (EPRI) Energy Analysis and Environment and Advanced Power Systems Division Committoes; EPRI Steam Generators Owners Group; EPRI Fossil Fuels and Advanced Systems Division Committee; EPRI Fuel Cell Users Group Management Committee; Editorial Advisory Boards for the Solar Law Reporter and the Energy Resources; and Massachusetts Institute of Technology Corporation Visiting Committee for the Department of Nuclear Engineering.

Dr. Papay is presently a member of the American Nuclear Society; Pacific Coast Electrical Association; National Science Foundation Industrial Panel on Science and Technology; California State Polytechnic University, Pomona, School of Science Advisory Council; California State University; Fullerton, School of Mathmatics, Science and Engineering Advisory Council; Renewable Energy Institute Board of Directors; U.S. Department of Energy Solar Research and Development Panel of the Energy Research Advisory Committee; Edison Electric Institute Research Management Committee; and is the Chairperson of the Electric Power Research Institute senior research committees, the Research Advisory Committee.

Dr. Papay resides with his family in Arcadia, California.

Mr. **Fuqua**. Thank you very much, Larry.

Mr. Washom, we will be glad to hear from you now.

STATEMENT OF BYRON J. WASHOM, PRESIDENT, ADVANCO CORP.; AND VICE CHAIRMAN, SOLAR THERMAL DIVISION, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. **Washom**. Mr. Chairman, members of the committee, it is indeed a pleasure to appear once again before this subcommittee on behalf of the Solar Thermal Division of the Solar Energy Industries Association.

With your permission, Mr. Chairman, I would like to have my written testimony submitted for the record, and I will abbreviate my comments today.

Mr. **Fuqua**. Yes. Without objection, we will make your written statement part of the record, and you may summarize.

Mr. **Washom**. Thank you.

I have attached as appendix A to the testimony today our industry brochure, where you can read the proof-positive success that we have achieved with this Government-industry partnership. We would like to think of this success as the technical dividends that have been gained due to the support that this committee has provided the solar thermal industry.

Additionally, these dividends represent our chances of the highest probability of success in the commercial marketplace, if we can just continue to fund the technology development until the technical and economic risks that we now face become manageable by private industry.

As we have stated before, Mr. Chairman, before this committee, we do have a time schedule. If level funding of approximately $53 million for the components of these systems can be maintained through 1985 for central receivers and 1986 for parabolic dishes, then direct Federal support can cease, similar to our previously stated position for parabolic troughs in fiscal year 1983. So we are on an off-ramp schedule, to wean ourselves from the Federal budget if you will, and enter into the commercial marketplace.

The technical dividends that I have referenced include the comments that you have just heard from Dr. Papay on Solar 1 as well as the Solar 100 project. Additionally, we have within our industry four companies that are now engaged in the phase I cost-sharing detail design of central receiver systems that range from 33 to 60 megawatts in size, in a solar thermal application as well as solar thermal electric.

In the parabolic dish field, since the last time we testified before this committee, we have had quite a bit of technical success. First and foremost, in July 1982 the parabolic dish Stirling system was tested at the Edwards Air Force Base and produced a sunlight-to-electricity conversion efficiency of 29 percent. That conversion efficiency is the highest registered for any solar technology.

Additionally, in the Brayton module we have two parallel programs, one going at a smaller 7- to 8-kilowatt level, as well as a 22-kilowatt level, coupled with the solarized automotive gas turbine program.

And, finally, the organic Rankine module was tested and will go to final design with fiscal year 1982 funds.

In the parabolic trough field, we had the completion of the modular industrial solar retrofit program for industrial process heat users.

The sum total of these technical results is that we now, as an industry, have a market application ranging from very low-temperature, small industrial process heat projects to very large solar thermal electric projects.

No other technology has such a breadth and depth of applications. Paramount to the success of this technology is the extension of the Federal energy tax credits. We applaud the efforts of the chairman of this committee and Mr. Lujan for the introduction of H.R. 1775. The extension to the end of 1990 for the energy tax credits will aid us substantially in preparing the commercial marketplace and the finances for these long-lead programs in the future.

Additionally, the expansion to 25 percent of the energy tax credit has been universally acknowledged by the Industry Association as imperative. Foremost, the expansion will reacquire, and a little bit more, that ground that was lost with the passage of TEFRA this past year.

These two requests that we make of Congress this year—the first being in the budget and the second being with the energy tax credit—are in complete consistency with the recent report from the Energy Research Advisory Board that you referenced in your opening comments. I have attached the solar thermal chapter on the ERAB report as appendix to my testimony.

This blue ribbon committee report to the Deputy Secretary of Energy stated three important points regarding solar thermal, and I would like to quote them. First, for the central receiver program:

> The cost sharing of receiver and storage concepts and support of private industry endeavors by continued Federal support for the operation of Solar One, system component development and test at CRTF; cost-shared support for repowering; and extension of the business energy tax credit.

Two, for the parabolic dish program, DOE should "redirect its emphasis to this program to further technology development. Small multimodule experiments should be planned on a cost-sharing basis."

Finally, for the technology base R&D programs, "a sharper focused program with priorities in optics, thermal, and structural materials, thermodynamics heat and mass production and fuel production."

The Industry Association this year has commissioned six different studies to provide Congress, DOE, and the executive branch the opportunity to see who we are, what we are, and what we are working for.

We have commissioned studies that are now attached in the testimony here relating to the status of the industry. We are composed of very large aerospace companies as well as small high-tech companies such as my own.

We have made comments regarding the 1983 budget and our consensus on that.

We have also been concerned with the Public Utility Regulatory Policy Act and particularly section 210 that is under debate by the courts and the administration.

We have come to a firm position on the tax credits that is consistent, coincidentally, with the position in H.R. 1775.

We have dealt with the issue of market assessment.

Finally, we have stated the impediments to raising capital for this capital-intensive, unconventional energy technology.

To turn to the issue of budget for fiscal year 1984, on page 22 of my prepared testimony, there is a breakdown of that budget followed by a paragraph-by-paragraph discussion of why we feel this technology should be supported.

I will forego the discussion of it item by item, but if I may just highlight a few items, I would like to do so.

First, under long-term research, the Industries Association has suggested approximately $6 million that will be done in a generic sense. Virtually all of the work that is being done under this program is equally applicable to parabolic trough, parabolic dishes, and the central receiver program.

Under the parabolic dish program, we now see the opportunity to subscribe to the ERAB recommendation and redirect DOE's emphasis to this program. The most important thing at this time is to provide the component development of the three industrial module teams that have been created under competitive procurement by DOE. This will lead to at least three companies being competitive in at least three different engine type technologies, all three of which will have an equal opportunity to be competitive in the marketplace.

We additionally look for system test and evaluation opportunities in what have been known as small community projects in the past of approximately 100 kilowatts in size.

In the central receiver technology, Dr. Papay has mentioned the first two items of our budget, Barstow operations and the remaining work to be done. But we also emphasize the need for a follow-on of phases II and III of the repowering project at approximately a level of $8 million in fiscal year 1984, with an understanding that another $4 million would be needed in fiscal year 1985.

The balance of the program is distributed to program management, solar salt ponds, and some very small remaining work to be done in parabolic troughs.

In conclusion, let me say that this technology and this industry have spent the money for the Department of Energy extremely well. We have hardware in the field. We have technical results. Our industry represents the world leaders. We are more anxious than anyone else to get on with the commercialization of this technology once the component development is completed.

Thank you.

[The prepared statement of Mr. Washom follows:]

STATEMENT OF
BYRON J. WASHOM
VICE CHAIRMAN
SOLAR THERMAL DIVISION
SOLAR ENERGY INDUSTRIES ASSOCIATION

BEFORE THE
SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS
OF THE
COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

MARCH 15, 1983

1.0 ABSTRACT

As a result of the government-industry partnership that is occurring, the past year has seen a number of significant accomplishments for the solar thermal industry. Among these are the operation of the Solar I central receiver system, the repowering preliminary design cost sharing programs, the Solar 100 solicitation, the successful testing of the Dish-Stirling system, and the successful Modular Industrial Solar Retrofit (MISR) program. The central receiver and the Dish technologies are in a critical stage of development and require continued direct DOE support through FY 1985 and FY 1986, respectively, in order to cross over into commercial viability. Direct support of the parabolic trough industry can be phased out in FY 1983. An extension and enhancement of the Federal Energy tax credits is required to assist these fledgling industries to compete and attract investment capital during the transition period to a seasoned, job-producing industry.

The solar industry, through the Solar Thermal Energy Association, recommends a budget of $53.2 million for solar thermal activities for FY 1984. The Association welcomes this opportunity to make this presentation to the Subcommittee on Energy Development and Applications.

2.0 INTRODUCTION

Mr. Chairman, members of the Committee, the Solar Thermal Division of the Solar Energy Industries Association is appreciative again this year of the opportunity to testify on the FY 1984 budget pertaining to the solar thermal technologies. Once again significant accomplishments and positive outlooks for the future have marked this past year as a result of the government-industry partnership that is occurring. As an industry association, we can now envision, with a level funded budget, a complete phaseout of direct Department of Energy funding by the end of FY 1985 for central receiver technologies and FY 1986 for parabolic dishes. (Parabolic troughs will be phased out in FY 1983.) At these dates, the remaining direct technical research and development risks will be regarded as manageable by private industry.

With regard to a related issue, we applaud and unequivocally support the Chairman's leadership in proposing an extension beyond 1985 of the Federal Energy Tax Credits which represent a more appropriate role for the government to take to help create this emerging high-technology industry.

2.1 STEA

The Solar Thermal Energy Association (STEA), a division of the Solar Energy Industries Association, is an industrial organization fulfilling a vital role in the commercialization of solar thermal systems. STEA member companies have consistently been at the forefront in advancing solar thermal technology through commitment of their own resources in close cooperation with federally supported research and development pograms in solar energy. Ranging in size from large, multinational, energy and aerospace corporations to small, innovative firms, STEA members are world leaders in solar thermal technology. This leadership is based on experience gained through the 1970s, beginning with the early efforts of the National Science Foundation Solar Program. Nearly 10 years of accelerated effort have led to the development of advanced system designs that have exceeded almost all performance expectations. The transition from early engineering and test prototypes to full-scale operating systems for industrial and utility users is nearing reality. Further information can be found in our brochure which appears as Appendix A.

2.2 TECHNICAL DIVIDENDS

Industry has responded to the policy shifts in energy research and development by advocating and implementing an orderly transition from system level engineering to a more research and applied development program. Important at this stage in this technology's development is the need to preserve the vast federal and corporate investment represented by existing test facilities. It is also important to continue and complete the component development program and last-step engineering phases that will help propel industry over the last major research and development risks that remain.

I know of no other renewable energy program that has met with more technical success, given the magnitude of the technical complexity. The government-industry partnership is working, and the end of direct support is within sight. A maximum of 3 years of additional direct support of the major technologies at less-than-level funding, relative to FY 1983, would appear to be adequate to complete the transition.

I firmly believe that the balance of this testimony will establish that there are significant technical dividends that have resulted from this committee's support of solar thermal technologies. I also believe that the work accomplished to date and the prospects for the future justify our FY 1984 budget request.

2.3 ERAB REPORT

The FY 1984 program that is proposed today is highly supportive of the recommendations made by the Energy Research Advisory Board to the Deputy Secretary of DOE on October 12, 1982 (see Appendix B). The ERAB report, which was requested by the Chairman of this Committee, established the state of the industry and the appropriate roles for future solar thermal research and development. The ERAB recommendations include:

1. For the central receiver program, the cost sharing of receiver and storage concepts, and support of private industry endeavors by continued federal support for the operation of Solar One, system component development and tests at CRTF, cost-shared support for repowering and extension of the business energy tax credits.

2. For the parabolic dish program, DOE should redirect its emphasis to this program to further technology development. Small multi-module experiments should be planned on a cost-sharing basis.

3. For the technology base R&D program, a sharper focused program with priorities in optics, thermal and structural materials, thermodynamics heat, and mass production and fuels production.

3.0 SIGNIFICANT ACCOMPLISHMENTS

3.1 CENTRAL RECEIVER

The past year has seen several significant events heralding the development of the solar central receiver as a viable energy source:

1) The 10-MWe, Solar I power plant near Barstow, California, became operational and was dedicated in November 1982.
2) Four repowering preliminary design contracts with cost sharing between industry and DOE were established.
3) Southern California Edison requested proposals from industry from a Solar 100 plant and received four responses.

3.1.1 Solar I

The 10-MW solar thermal central receiver pilot plant became operational in April 1982 and is currently the world's largest electric generating station powered by solar energy.

This plant was the result of a joint effort between Southern California Edison, the Los Angeles Department of Water and Power, the California Energy Commission, and the U.S. Department of Energy. The plant has operated at 10.4-MW net electrical output, which is slightly in excess of its rated output, and has produced over 1,369,000 kWh of net energy. Very recently, a power of 7.3 MWe from storage was achieved, an accomplishment which satisfies another design milestone for the plant. It is especially noteworthy that within the last few months, the plant has exhibited an availability of greater than 90% and that more than 98% of the heliostats are capable of operation at any given time. The latter fact is especially important relative to the acceptability of this energy option to the user industry.

The 5-year test program is well underway and the pilot plant has demonstrated that the central receiver concept works as expected. The first 2 years of the test program will be devoted to design verification of the individual systems and components, and will serve to verify the various modes of operation. Additionally, controls will be updated so the plant can be operated with a minimum operating staff, and the collector system will be integrated into the overall control system. The last 3 years of the program will maximize kWh output and demonstrate plant reliability.

3.1.2 Repowering

Four preliminary design studies for solar central receiver power plants are underway. These preliminary design contracts involve significant cost sharing between the industry participants and the DOE. Three of these plants are for utility power generation operations with sizes from 30 to 66 MWe. These three plants represent the use of liquid sodium, molten salt, and water as the heat transport fluid. The fourth preliminary design is a 31.8-MWe cogeneration project in Hawaii using water as the heat transport fluid. Three of these projects are midway through the contract phase, but the concept that utilized sodium as a heat transfer fluid is based on an accelerated schedule in order to attempt to be on line in mid-1986. The results to date from all projects have verified performance characteristics, reduced technical uncertainties associated with operating activities such as startup and shutdown, and reduced cost uncertainties.

All of these projects are struggling to maintain favorable economic characteristics for the plants in the face of decreasing fossil fuel costs and the potential loss of the energy tax credits after 1985.

The industry looks forward to the soon-to-be released PON for the final design effort on repowering and for subsystem research experiments in fulfillment of Congressional guidance.

3.1.3 Solar 100

Southern California Edison has been a leading utility in expressing interest in renewable energy sources, with a commitment to 2100 MW by the early 1990s. Of this, 350 MW electric has been designated to come from solar energy. SCE has given considerable incentive to industry through its Solar 100 solicitation. However, SCE is not in a position to buy a plant but would buy power from the plant. Hence, the capital investment required would depend on third party financing.

The four companies that responded to the SCE request for proposal expressed confidence in the technologies that are available and optimism that financing can possibly be worked out. However, at least one of the companies preferred a power level intermediate between Solar I and Solar 100 on the basis of developing the technology in smaller steps and reducing the amount of financing required. The decreasing avoided fuel costs makes the raising of third party capital increasingly difficult.

3.2 PARABOLIC DISH

During the past year, the U.S. Department of Energy continued to coordinate the development of Rankine, Stirling, and Brayton engine/receiver combinations. Since I spoke last March, additional significant milestones have been reached on the path of developing dish electric systems for efficiently and reliably producing electricity. The development of the Stirling engine technology has been enhanced by substantial cost-sharing activities between industry and DOE. In April 1982, testing confirmed the technical feasibility of a hybrid (i.e., combustion-augmented) dish Stirling receiver. After reviewing several competing proposals, DOE signed a cooperative agreement in May 1982 with a team of industrial contracts for a cost-shared experiment for the design, fabrication, assembly, and test of an entire dish Stirling module. Under its own resources, the engine manufacturer designed and fabricated three experimental solar-only receivers and one engine. Under a joint industry-government project that had significant cost sharing by the industrial participant, a full system test was carried out and demonstrated an electrical power output of 24 kWe near solar noon on July 15, 1982. This event set a new record in solar energy development, since a solar-to-electric conversion efficiency of approximately 29% was recorded. This efficiency is the highest achieved to date by any solar energy conversion technology.

A two-phased approach to developing the Brayton-cycle technology was recommended in a system tradeoff study completed in April 1982. The study concluded that the first near-term Brayton module should use a small 8-meter-diameter parabolic dish designed and funded entirely by industry. This dish would be coupled with the subatmospheric Brayton-cycle (SABC) engine under development in the Gas Research Institute program. This study recommended that subsequent, more advanced system designs should incorporate the high-efficiency Brayton technology based on the ceramic advanced gas turbine (AGT) which is currently under development in DOE's Automotive Engine Program. During the past year, industry initiated testing of the advanced gas turbine at an industry facility and fabricated an early solarized version using a metal turbine wheel rather than one constructed of ceramic. The solarized advanced gas turbine (SAGT-1) was combined with an air-Brayton receiver and will be tested at the Parabolic Dish Test Site this summer.

The organic Rankine-cycle technology will be field tested in the Small Community Experiment. In July 1982, DOE announced its selection of Osage City, Kansas, as the prime site for the experiment, with Molokai, Hawaii, as a backup. As a preliminary step in this experiment, verification testing of the organic Rankine-cycle power conversion assembly on a test bed concentrator was completed at the Parabolic Dish Test Site in April 1982. The maximum power output achieved during the testing was 16 kWe with an overall module efficiency of 19%.

In September 1982, the fabrication and installation of a prototype dish concentrator was completed. Characterization testing of this prototype concentrator with a plastic-film reflective surface is nearing completion at the PDTS. A thermal output of 75 kW, which approaches the expected performance level, was achieved in February 1983.

3.3 PARABOLIC TROUGH TECHNOLOGY

Line focus technology is generally accepted as ready for commercialization, and, in a general sense, this conclusion is true. All manufacturers of parabolic trough collectors are currently marketing, with some success, to industry without DOE subsidy. The basic systems are well developed and not in need of continued support by DOE in terms of development of the specific parabolic trough concept.

The basic system characteristics are fairly well understood, with IPH systems being the most developed. The Modular Industrial Solar Retrofit (MISR) Program, supported by DOE funding, has been very successful and has resulted in the completion of the concept design phase of the line focus development program. The MISR concept features as modular solar industrial steam system and is the final phase of testing and component improvement.

There remains one small area of line focus technology development which is in need of DOE support in a generic sense; i.e., the work will be of use to several technologies. This area is one of high-risk research and material development. Of particular importance is consideration of reduction of thermal loss from the receiver subsystem and the enhancement of reliability and performance therefrom.

Some of the materials which require further development support are reflective surfaces, antireflective coating, selective coatings, seals, and heat transfer fluids. It is the opinion of the parabolic trough industry that this development support can be most effectively implemented at Sandia National Laboratories in Albuquerque.

Completion and support of current IPH experiments, along with continued support of high-risk material research, will achieve the goal set for the line focus technology.

4.0 STATE OF THE INDUSTRY

4.1 EXCERPTS FROM SEIA REPORTS

SEIA has prepared a number of reports regarding the status of the solar thermal industry, the international market, program plans, and government incentives. These reports can be summarized as follows:

1) Status of the Solar Thermal Industry: An Assessment, December 1982

"The solar thermal industry, which includes companies developing parabolic dish, parabolic trough, and central receiver systems, is on the verge of commercialization. Though it faces no major technological problems as a new and vulnerable industry that has yet to make its first significant private commercial sale, it is still quite dependent on federal support in the form of R&D, field engineering tests, and tax credits. Twelve out of sixteen solar thermal companies considered in this report are dependent on direct government support to a substantial degree. Half of these are getting 25-50% of their R&D funds from the government, the other half are 80-100% dependent. The four currently not getting federal support had been [getting such support] until recently. One-third of the respondents believed their companies would drop out of solar thermal development if direct federal support were cut off. Those most likely to drop out were central receiver and dish companies; trough company respondents believed their companies would be set back, but probably would not be forced out of business."

2) DOE Solar Thermal Energy Program On-Line Budget Analysis 1983 (January 1983)

"In regard to DOE FY 1983 planning, industry is most interested in technology R&D that helps it get currently conceived projects off the ground. There is less appreciation for large sums of money being spent on more sophisticated, longer range concepts, such as a solid particle receiver concept. The industry appreciates the apparent need to mollify the Administration with "long range, high risk" approaches but it is not willing to go along at the expense of dissipating near-term momentum from the pre-existing program. DOE appears to have failed to adequately project a long-range strategy for solar thermal energy development that would disarm industry fears of the program being cut well beyond the bone."

3) Section 210 of PURPA and Solar Thermal Energy Development: The Current Regulatory Environment and Suggestions for Future Action (January 1983)

"On a macro-scale, PURPA §210 and its implementation to date by FERC and State regulatory authorities have created a regulatory environment which is basically favorable to solar thermal and other QF development. A much larger number of solar thermal facilities are being planned, proposed and negotiated than was the case prior to PURPA. Although PURPA cannot be demonstrated conclusively to be the principal cause for increased interest in solar thermal facilities, PURPA appears to be a contributor to favorable conditions for solar thermal development. PURPA seems to be accomplishing its major objectives of exempting QF's from burdensome regulation as electric utilities, and creating a climate for fruitful discussions with electric utilities."

The report contains a summary and analysis of possible amendments to PURPA with the following subject matter:

1. Raising the maximum power level for small power production facilities
2. Eliminating or altering current PURPA restrictions or utility ownership of QF's
3. Easing interconnection
4. Rates for QF-generated electricity
5. Interconnection costs
6. Extending exemptions from other laws.

4) Options for Federal Income Tax Incentives for the Solar Energy Industry (February 1983)

"Federal income tax incentives can play an important role in carrying out our national policy of encouraging and accelerating the development of the solar energy industry. In the past, American economic policy has been to support declining industries, whereas the economic policy of some more rapidly expanding nations, such as Japan, has been to encourage new industries. A program of support, including tax incentives, for the solar energy industry would encourage a new industry which may become crucial to U.S. security and economic stability.

"To offer the greatest probability of success, the tax incentives should include provisions benefiting consumers of solar products, manufacturers of such products, and investors in such manufacturers. Incentives to consumers will encourage development of a market for solar products which will present manufacturers with a source of funding, provide them with experience in marketing, and afford opportunities to test and improve products. Incentives for the manufacturers and investors will encourage capital formation in the solar industry through tax shelters, venture capital and more conventional investments, and by reducing the tax drain on such capital. Tax incentives could obviate or reduce the need for direct government support of the industry, and, by contributing to the more rapid growth of the industry, create jobs, income and tax revenues."

5) International Solar Thermal Market Assessments: An Evaluation (December 1982)

"Most of the international market assessments for solar energy are useful only as introductions to help exporters decide which countries to choose for future study. These reports contain general background material, such as energy resource data, rather than rigorous economic analyses or sales projections as a potential exporter of solar thermal systems needs to make real investment decisions. The market assessments, mostly for third world countries, focus on low temperature, solar heating and cooling, and photovoltaic technologies that can be used in small scale, remote site, and rural applications, and therefore seem more suitable for less developed nations. The reports largely ignore the possibilities for large scale, solar thermal electric power plants."

6) Impediments to Capital Formation in Solar Thermal Energy Systems (February 1983)

"A firm's decision to invest in a particular project is dependent upon a number of factors, chief among them are the availability of capital, the cost to the firm of that capital, the anticipated future stream of earnings associated with a specific project in the light of any uncertainties inherent in that stream, and the appropriateness of a given project within the firm's overall investment portfolio. To attract capital, a solar thermal project must possess two basic attributes. First, it must provide returns, in the form of future earnings or avoided costs, that are commensurate with its perceived risks (both financial and techical). The old maxim that high risk goes with high reward, low risk with low reward is apt. Beyond this, it must be apparent to potential investors that the magnitude and certainty of such returns are preferable to alternative investments currently available including fossil, wind, etc. As much less commercial experience exists with respect to solar thermal than its competitors, it is strongly penalized for risk. That is, the quality of returns, being less certain, is heavily discounted. More commercial experience with solar thermal is necessary before such fears can be allayed.

"Given the current outlook for energy prices and the investment climate, the continued development of a commercial solar thermal industry in the mid to late 1980s is depending on strong Federal initiative.

7) Solar Thermal Program Strategy (January 1983)

"Neither potential users of solar thermal energy systems nor the investment banking community appear willing to accept the large risk at the present time in adopting solar energy systems, except for some recent cases applying to trough and photovoltaic projects. This means the federal government must continue to support, at a minimum, and with substantial cost sharing by industry, component and subsystem testing so that users can be convinced of the merits of the technology. This immediate agenda must be continued and then complemented with the longer range view. There is a danger DOE would emphasize longer range research and development before the first phase in solar thermal development is really complete; that is, carrying current technology into a safety zone which ensures a solar thermal industry exists to benefit meaningfully from longer range development.

"Industry is accused of being so preoccupied with nearer-term development of solar thermal technology and its commercialization that it ignores the implications of what needs to be done in the mid-term to ensure a smooth transition to the satisfaction of longer range goals. The industry contends that it has adopted a responsive position, manifest in its proposals that funding for current technologies (troughs, dishes, and central receivers) phase out in the mid 1980s. There remains a gap, however, in the positions taken by industry and the Administration over strategy. A closing of the gap must still be accomplished if the solar thermal program is to proceed smoothly through the 1980s to realize its long-term potential."

4.2 ENERGY TAX CREDIT EXTENSION

The Solar Thermal Division of SEIA recognizes and agrees that there is a need to reduce federal spending in the near term and that direct federal support for certain specific solar systems should be phased out in an orderly and timely manner. In keeping with this strategy, the industry recommended significant reductions in solar thermal budgets for FY 1983, proposed significant cost-sharing arrangements under those budgets, and presented a phaseout strategy whereby direct support ended for the parabolic trough technologies, for the central receiver technologies, and for the parabolic dish technologies at the end of FY's 1983, 1985, and 1986, respectively. Under these circumstances, the industry's understanding was that the 15% energy tax credit, the depreciation schedule of 5 years for certain solar energy equipment, various provisions of PURPA, and other key off-budget items would remain intact as an aid in getting the technologies into the private sector. However, in the interim, the Tax Equity and Fiscal Responsibility Act (TEFRA) of 1982, which significantly reduces the effective value of the tax credit, was passed. In addition, there has been frequent pressure put forth by the Administration to delete the tax credit altogether, and, finally, there is now developing a thrust to change the depreciation schedule. All of these factors have a strong deleterious effect on industry's goal of getting these solar technologies completely into the private sector where they can be commercialized and where they can make a significant contribution to our energy options and energy independence.

In view of these circumstances, the Solar Thermal Division of SEIA developed a tax credit position late last year and now feels that it is essential that an energy tax credit at the 25% level be made available over the time period from the present to December 31, 1990, and that a provision be included to extend the credit at the 25% level to December 31, 1993, for projects that have made an affirmative commitment to construct by the December 31, 1990, date. There are several reasons why we feel that this request is reasonable.

First, the 25% tax credit effectively restores, with a slight margin of enhancement, the tax credit to the value it had prior to TEFRA. Secondly, many projects require 3 to 4 years to carry out, and money, in some cases in the amount of several hundred million dollars, must be raised at the beginning. Thus, projects of this type cannot be planned and money probably cannot be raised by investment bankers if the current December 31, 1985, termination date remains in effect. In summary, an extension to the 1993 time period is essential to plan and carry out the many large and small projects which will have a strong influence on the users industries in terms of adopting the technology under a purely free-market situation. In addition the stability of the tax credit legislation provisions, as well as a host of other related legislation such as PURPA and depreciation schedules, is essential to the success of transferring these technologies to the private sector.

The Industry Association applauds the Chairman's initiative in introducing HR 1775 which we feel will well meet the needs of the industry.

4.3 DWINDLING OIL PRICES

A reasonable question at this time would be to speculate as to the impact of dwindling oil prices on the commercialization of the solar thermal technologies. It is not possible to specifically state the impact with any degree of certainty, but several generalities can be offered.

First, a sustained reduction in oil prices will delay the introduction of these technologies and possible extend the payback of the projects that are eminent. Conversely, if lower oil prices significantly increase the economic recovery and lower interest rates occur, then the financing of these systems will be enhanced.

Second, from a public interest viewpoint, we are deeply concerned over the number of large synthetic fuel, oil, and gas exploration and alternate fuels projects that are being terminated or indefinitely suspended over this current event. I am sure it has not gone unnoticed that such terminations will keep America indefinitely vulnerable to OPEC and/or any supply disruptions caused by political, military, or terrorist actions abroad. The relatively short lead times required to implement solar thermal technologies and their long-term growth potential as an alternative to fossil fuel is our most persuasive argument for a sustained industry-government partnership in developing renewable energy technologies.

5.0 PROPOSED FY 1984 BUDGET

The Administration's FY 1984 budget request for the Solar Thermal Technologies discussed today is only $13.4 million. This figure represents only a fraction of the past solar thermal budgets and for the third year in a row, the Administration has formulated a budget request that is less than one-third of the preceding year's authorization.

The STEA considers the Administration request inadequate in light of the significant accomplishments and the remaining tasks. Included herein is a comprehensive alternative budget that totals $53.2 million. In the next section we have spelled out our rationale for each line item and we feel that our submission represents a realistic and balanced approach to the development of solar thermal energy. The difference in the two budget requests represents the difference between having a viable, job-producing industry, or potentially none at all.

SOLAR THERMAL ENERGY ASSOCIATION
BUDGET RECOMMENDATIONS
FY 1984
(DOLLARS IN MILLIONS)

LONG-TERM RESEARCH		5.9
1. Materials	2.0	
2. Collectors and Concentrators	0.5	
3. University Thermal Research	1.4	
4. Sunfuels Research	2.0	
CENTRAL RECEIVER RESEARCH AND TECHNOLOGY		2.0
1. CRTF Operations	2.0	
PARABOLIC DISH RESEARCH AND PROJECTS		16.0
1. Component Development of Modules	7.0	
2. Advanced Concentrator Development	2.5	
3. System Test and Evaluation	3.5	
4. Applied Research and Test Facilities	3.0	
SOLAR PONDS		0.5
CENTRAL RECEIVER SYSTEMS		25.3
1. Barstow Automation and Controls Software	4.2	
2. Barstow Operations, Maintenance, and Analysis	5.0	
3. Repowering	8.0	
4. Receiver Development	4.1	
5. Storage Concept Development	1.0	
6. Steam Generator Development	3.0	
DISTRIBUTED RECEIVER SYSTEMS		1.5
1. Operations and Evaluations	1.5	
PLANNING AND PROGRAM SUPPORT		2.0
		53.2

SOLAR THERMAL DIVISION
SOLAR ENERGY INDUSTRIES ASSOCIATION
BUDGET RECOMMENDATIONS AND SUBSTANTIATIONS FOR FY 1984

The rationale for each item in the STEA budget recommendations is presented in this section.

LONG-TERM RESEARCH

1. MATERIALS

Although materials are available to fabricate and operate solar thermal systems successfully at the present state of the art, there is room for improvements in this area both from the standpoint of performance and cost reduction. In the long term, improved materials will make all of these technologies more efficient and therefore more cost competitive with other energy alternatives. Such long-term, generic research falls within current DOE guidelines in terms of risk and the time it takes for such research to be adopted by the private sector. STEA recommends generic research at a $2.0 million level for FY 1984 in such areas as reflective surfaces, anti-reflective coatings, selective coatings, seals, improved glass, and higher strength materials.

2. COLLECTORS AND CONCENTRATORS

Many aspects of collector and concentrator research are generic in nature and apply in one degree or another to parabolic troughs, parabolic dishes, central receivers, and other solar systems. In this area, work that results in improved performance and in reduction in capital costs, or both, is important to the long-term viability of solar thermal system. The industry feels that this line of investigation is justified and recommends $0.5 million be expended in FY 1984.

3. UNIVERSITY THERMAL RESEARCH

Research work carried out by U.S. universities has been useful in the past in identifying promising concepts and processes in solar thermal technology. The industry feels that such work should be continued in FY 1984 and beyond at the $1.4 million level in 1984 dollars. In the view of industry, this research should have a very general goal of identifying, analyzing, and carrying out laboratory scale and test facility experiments on processes that can potentially have a significant impact on energy independence, stabilization of energy prices, and reduction of energy imports.

4. SUNFUELS RESEARCH

Although the solar thermal industry recommends that R&D in the area of the application of solar thermal processes to the production of fuels and chemicals be conducted, we do not feel that it should have a high priority since it cannot have a near-term impact on stabilization of energy prices or on energy independence. We do feel, however, that a $2.0 million effort is justified, provided it is expended on research of processes and systems that can potentially apply to a broad range of current industrial processes and products. Even though, for example, a long-term goal of producing hydrogen by means of thermochemical processes appears to be promising, that goal should be reached via analyses, research, and development which can be of use to the U.S. industry in the near term. The industry feels that funding for research and development in the field of fuels and chemicals should be kept at a low level until the nearer-term technology development applying to the parabolic dish, central receivers, and parabolic troughs is at a stage at which it can and will be picked up by the private sector for commercialization. Out-year budgets for sunfuels are, therefore, recommended for increases consistent with the potential impact that the fuels and chemicals systems can have on the U.S. energy situation.

CENTRAL RECEIVER RESEARCH AND TECHNOLOGY - CRTF OPERATIONS

The CRTF is an essential research tool in the development of the solar central receiver. The very nature of the solar source, its frequency distribution, its diffuse nature, and its variability with time, location, and weather conditions dictate that solar energy concepts be verified under real solar conditions. The ability to transfer the solar central receiver technology to the private sector at any time will depend to some extent on the degree to which the technical feasibility of the process or the performance of a component has been verified at a real solar source. In addition, private industry anticipates a need to have facilities available (much like those available for high energy physics or nuclear research) at which testing can be conducted on hardware designed and fabricated by private industry. Any given private organization could not afford or justify keeping a facility active on the basis of the infrequent times at which its own needs must be met. Industry feels, therefore, that this need should be logically and properly be met by Federal involvement. A budget of $2.0 million is recommended for FY 1984, and similar budgets are required for out-years for this facility.

PARABOLIC DISH RESEARCH AND PROJECTS

1. COMPONENT DEVELOPMENT OF MODULES

Three industrial teams have been selected through competitive procurements to develop fully integrated modules in one of three separate engine types. Funds will be provided to these established teams to continue research and development on specific areas that have been identified as significantly reducing capital cost, increasing output, or extending the useful life. Due to variations in development and funding history, the Brayton modules shall receive $3.5 million, including the Solarized Automotive Gas Turbine. A total of $3.0 million is requested for the Stirling module and $0.5 million for the Organic Rankine module.*

2. ADVANCED CONCENTRATOR DEVELOPMENT

Generic to all three modules is the future need to develop a significantly lower cost, high performance concentrator similar to the accomplishments achieved by the second-generation heliostat effort. At least two detailed designs will proceed in FY 1984 for $2.5 million.

3. SYSTEM TEST AND EVALUATION

System test and evaluation of the three modules is the critical last step to reaching commercialization.. FY 1984 will provide the Organic Rankine test at Osage City with $0.5 million* in operating and spare parts, $0.8 million for the second test of Stirling and/or Brayton, and $2.2 million for the third system test and evaluation of the module system not previously chosen. Outyear requirements will be an additional $3.0 million for 2 years.

---

*It is assumed that the FY 1982 appropriated funds of $4.0 million and the programmed FY 1983 funds of $3.0 million will be augmented with a total $1.0 million in FY 1984 and $0.6 million in FY 1985 in order to complete the organic rankine module development and build and operate a 100-kW system test and experiment.

4. APPLIED RESEARCH AND TEST FACILITIES

This item covers applied research for materials, thermodynamics, and optical analysis and is estimated to require $2.0 million. Approximately $1.0 million is required for operation of the Parabolic Dish Test Site.

SALT POND RESEARCH

The solar thermal industry feels that research and development on solar pond concepts, although they can potentially lead to a technology that might have a significant impact on the U.S. energy situation, should be funded at a low level of the order of $0.5 million for FY 1984 and should then increase in out-years consistent with the potential predicted by the early R&D. In part, this recommendation is based upon a recognition of the fact that funding resources on the part of the federal government are now and will be limited for the near future, and that we feel that other technologies, further along toward feasibility, should be gotten into the private sector first.

CENTRAL RECEIVER SYSTEMS

1. BARSTOW AUTOMATION AND CONTROLS SOFTWARE

The Barstow Solar I plant is providing valuable operating data. An amount of $4.2 million is requested to provide automation and controls software. Plant automation will result in increased plant operating time and decreased operator workload. The items that are to be specifically provided:

a. Automated sequences and transitions for plant startup
b. Clear and cloudy day operating scenarios
c. Supervisory controls to manage the plant resources using the operating computer system (with fewer operators)

2. BARSTOW OPERATIONS, MAINTENANCE AND ANALYSIS

This item provides $5.0 million for the continued operation of the Barstow plant and the test and evaluation activities:

a. An analysis of test data to compare predicted and actual plant parameters to verify design performance. Operating strategies will be identified to increase plant output and improved economics.

b. Collector (heliostat) tests and evaluations to derive beam pointing, beam quality, and reflectivity data. Heliostat cleaning requirements will be established.

c. Plant maintenance evaluations will be conducted, including the analysis of the reliability of equipment, the identification of preventive maintenance needs, and spares required for Solar I, as well as for future plants.

d. "Lessons learned" documentation for design, construction, and operational phases.

e. Environmental assessments and heliostat field ecological impact data for future plants.

Data dissemination through such technical transfer activities as conferences, workshops, and written reports. For FY 1985, operations and maintenance of the Barstow facility is expected to require $3.0 million and the completion of the Test and Evaluation activity, $2.0 million.

2. REPOWERING

The solar industry feels that the solar central receiver is close to, but not yet at, the point at which it can be turned over to the private sector. There remain three principal technical/cost barriers impeding the acceptance into the private sector. One of these is an uncertainty in the capital cost. Another is the uncertainty on the performance and cost of key components, such as the receiver at the top of the tower, the steam generator (especially reheaters), and storage. The third is that, because of a lack of mass production (on heliostats, in particular), the capital cost of the first few central receiver plants is likely to exceed their value in a free-market environment.

This section of the budget recommendations deals with alleviating the first of these problems. Subsequent sections will address the second issue. The third issue can be solved by means of the energy tax credit and will not be dealt with here since it is not a direct budgetary item. However, industry has already gone on record to indicate that an enhancement of the energy tax credit to 25% by December 31, 1990, is an absolutely essential element in successfully carrying out the transition of the technology to the private sector.

Under the four, current preliminary design efforts that are being sponsored by DOE under a cost-sharing arrangement, significant progress is being made toward reducing the capital cost uncertainties on solar central receiver that will be needed to fill the intermediate load demand market (approximately 30 MWe and larger, and all liquid-type coolants). However, in order to reduce this uncertainty to the point at which investment bankers can raise the necessary funds for private sector ventures, more refined designs must be carried out. At the present time, the risks associated with the actual cost is too high for the private sector to undertake a specific project. Under the FY 1983 recommendations made by the industry, a total of $15 million was requested for this type of work. However only $3.0 million was actually made available. Thus, the industry is requesting that $8.0 million be made available in FY 1984 to complete one of two final engineering designs and to initiate a second design. A sum of $4.0 million is requested for FY 1985 to complete the second design.

4. COMPONENT DEVELOPMENT AND TESTING

As was indicated above, one of the major barriers that impedes the ability of industry to pick up the central receiver technology is the high cost and high risk associated with the development of certain key central receiver components. Principally, these components are the receiver, the steam generator, and storage. The receiver is of particular concern since it does not have a direct counterpart in current industrial process systems. In order to reduce the perceived risk on this component to the point at which the private sector can pick it up and complete the development for commercialization, the industry recommends a base technology development effort which includes the receiver as well as the other two key components.

In FY 1983, a budget recommendation of $3.3 million was made for receiver development. Assuming that the DOE gets industry involvement on a cost-shared basis at this level during FY 1983, a budget of $4.1 million is requested for

FY 1984. This money will complete fabrication of the receiver test articles and components. A budget of about $3 million will be required during FY 1985 to complete the development and test of this component.

5. STORAGE CONCEPT DEVELOPMENT

The acceptance of the central receiver as a viable energy option will be greatly enhanced by the development of a storage system that is low in cost and economically viable for use in achieving gross base-load operation. Conceptual feasibility of at least one thermal energy storage system meeting these criteria has been identified and analyzed. However, technical performance and operating characteristics need to be verified before the private sector can take over the engineering development and application. The design, fabrication, test, and analysis of a test article of sufficient size to verify development potential is estimated to require a total of $2.9 million. Of the amount, $1.5 million is expected to be expended during FY 1983. During FY 1984, approximately $1.0 million is requested, with the balance of $0.4 million being needed for FY 1985.

6. STEAM GENERATOR DEVELOPMENT

Although both sodium and salt steam generators have been built and are at very different stages of development in the U.S., there are certain unique features that are required for the solar application that makes them fall outside of the capability of solely private sector development. One of these is the use of the steam generator in the reheater mode. Currently, there are no U.S. manufacturers of steam generators for this application. Another consideration is that the nominal operating temperatures are considerably higher in the solar application than those that have been achieved in industry. These factors have led to a recommendation for a FY 1984 budget of $3.0 million, assuming that funds in the amount of about $2.5 million are allocated by DOE under a cost-sharing arrangement in FY 1983 for the early phases of this work. A budget of approximately $2.4 million for FY 1985 would be expected to be sufficient to complete this development work.

DISTRIBUTED RECEIVER SYSTEMS - OPERATIONS AND EVALUATIONS

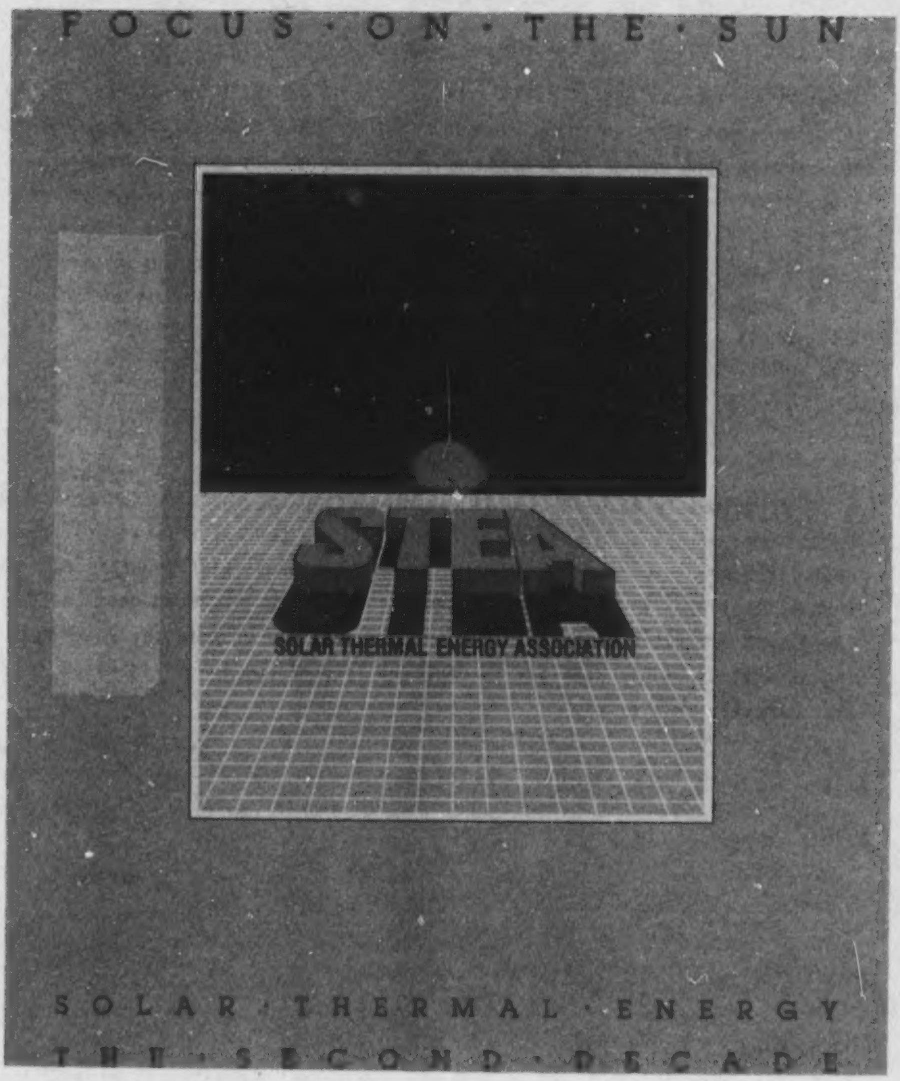
The industry recommends data acquisition and continued operation of existing systems at a $1.5-million level. It is in the best interest of the line focus industry and the government that existing federally funded systems be operated long enough to obtain useful data on system performance, degradation with time, reliability, maintainability, etc. Funds are required in FY 1984 to insure that systems which have recently come on line or have recently been upgraded will be operated for a sufficient period to permit useful data to be obtained so as to justify the investment of federal funds in the project. This activity is expected to continue through FY 1985 at this funding level.

PLANNING AND PROGRAM SUPPORT

Approximately $2.0 million is recommended by the industry for allocation in the area of planning and coordination of solar thermal activities. These activities should be directed toward all technologies, with emphasis on longer term activities. The industry opposes activities dealing with cost goals, since such activities tend to have a negative effect on private-sector marketing activities. This activity is expected to continue in out-years at approximately this level.

5056C/bes

APPENDIX A



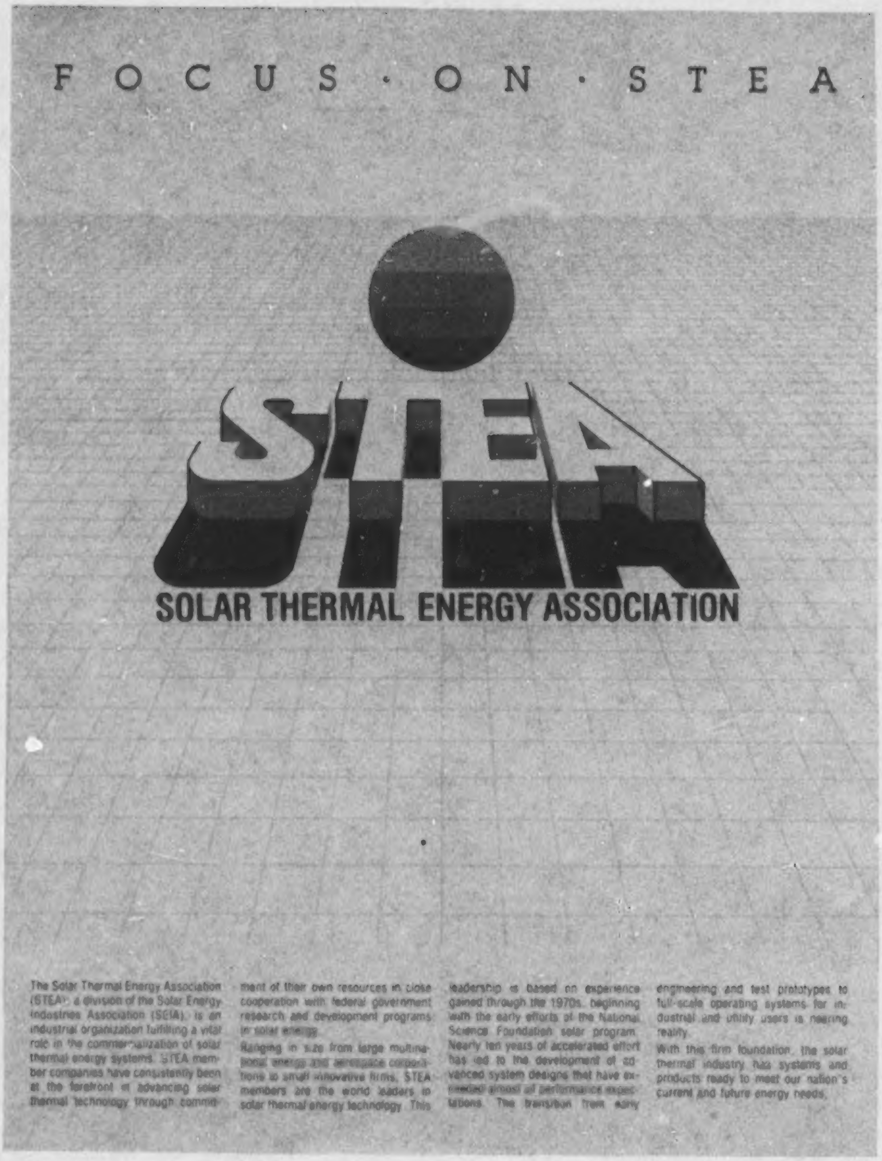
FOCUS · ON · THE · SUN

STEA

SOLAR THERMAL ENERGY ASSOCIATION

SOLAR · THERMAL · ENERGY

THE · SECOND · DECADE



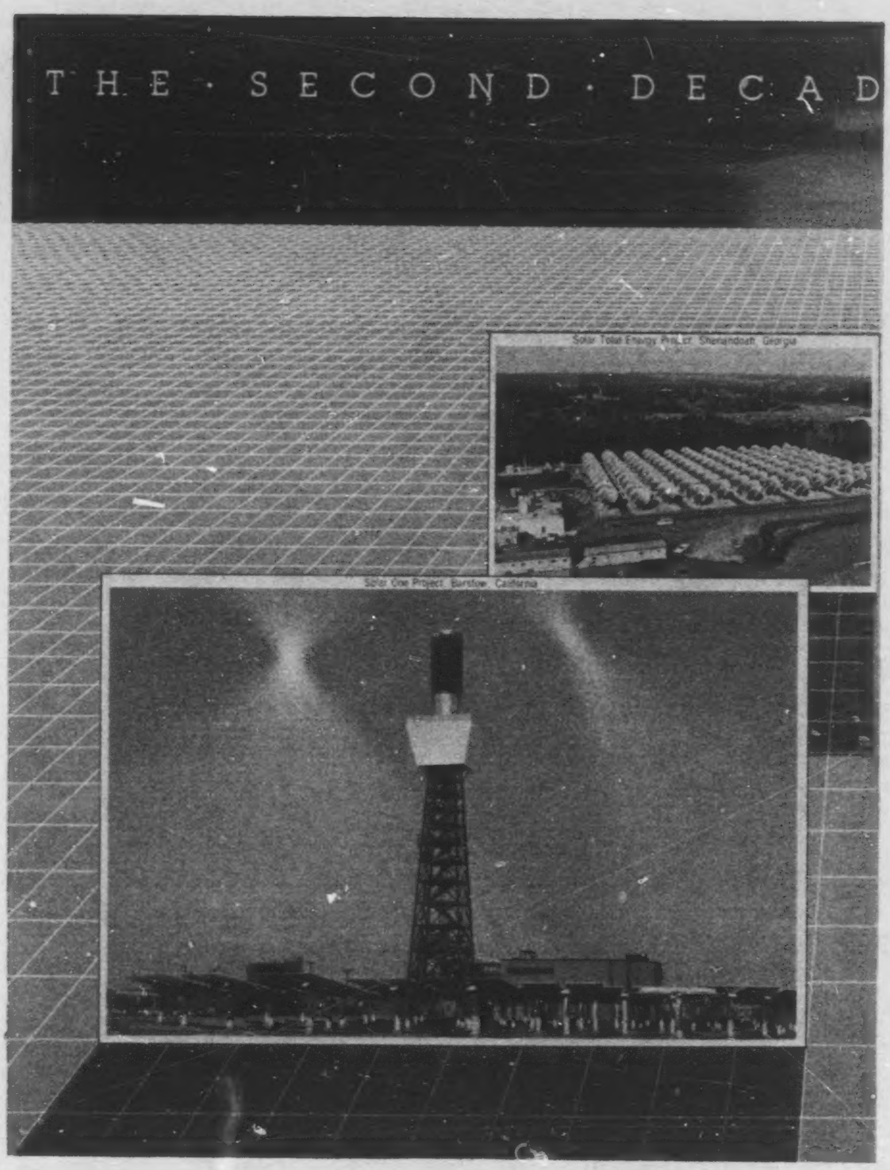
FOCUS · ON · STEA

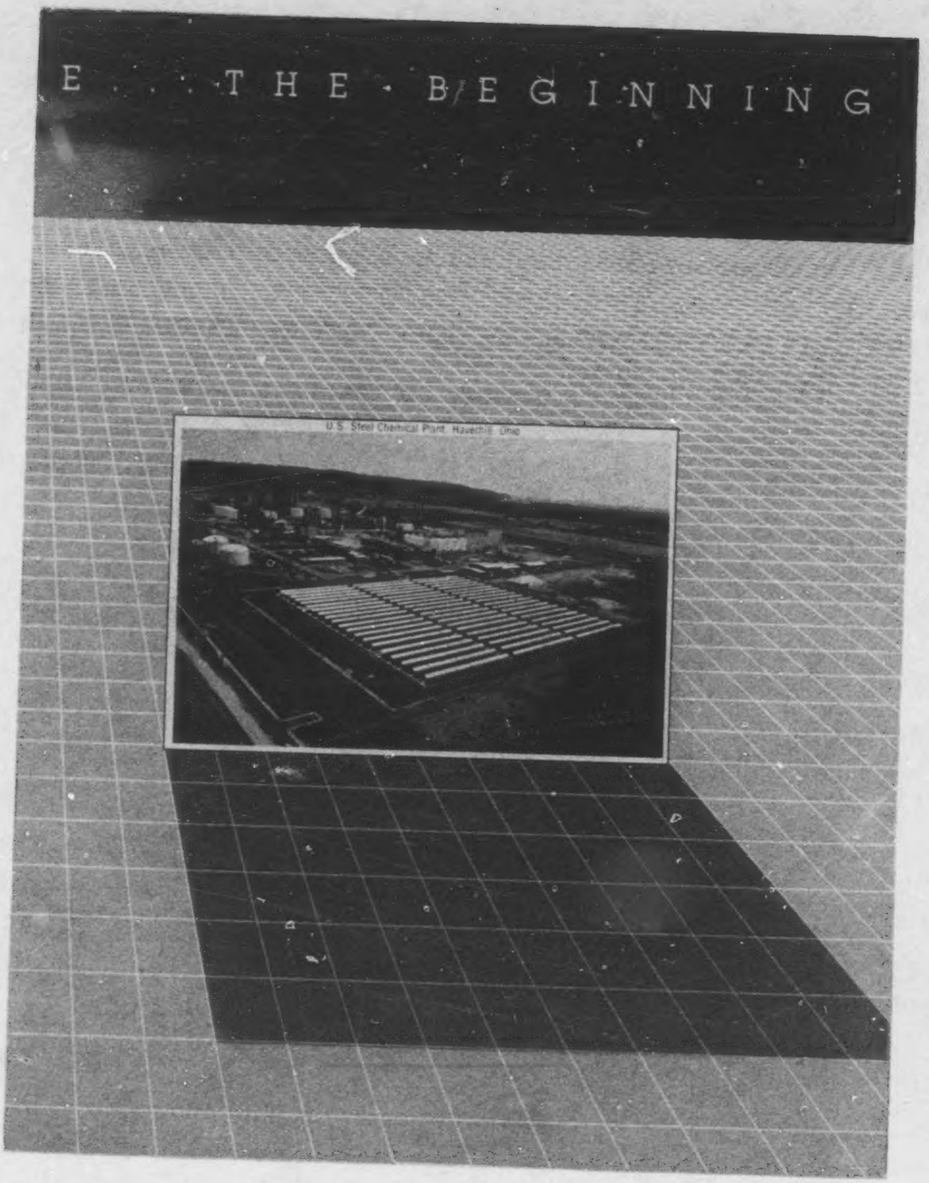
SOLAR THERMAL ENERGY ASSOCIATION

The Solar Thermal Energy Association (STEA), a division of the Solar Energy Industries Association (SEIA), is an industrial organization fulfilling a vital role in the commercialization of solar thermal energy systems. STEA member companies have consistently been at the forefront in advancing solar thermal technology through commitment of their own resources in close cooperation with federal government research and development programs in solar energy.

Ranging in size from large multinational energy and aerospace corporations to small innovative firms, STEA members are the world leaders in solar thermal energy technology. This leadership is based on experience gained through the 1970s, beginning with the early efforts of the National Science Foundation solar program. Nearly ten years of accelerated effort has led to the development of advanced system designs that have exceeded almost all performance expectations. The transition from early engineering and test prototypes to full-scale operating systems for industrial and utility users is nearing reality.

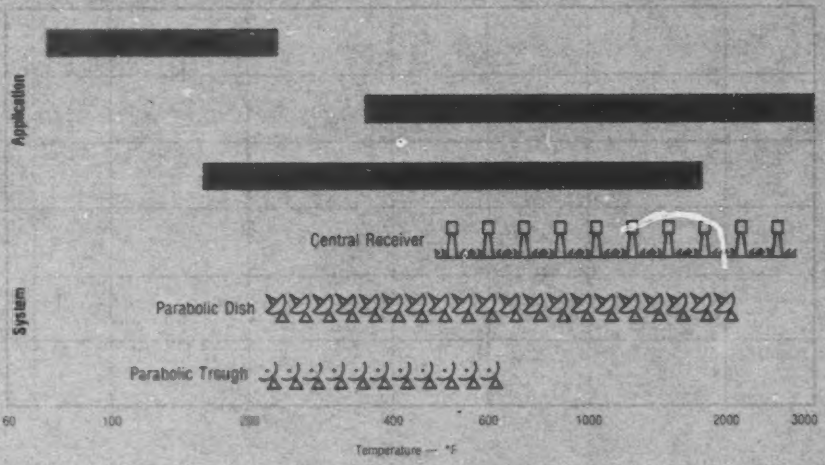
With this firm foundation, the solar thermal industry has systems and products ready to meet our nation's current and future energy needs.


THE · SECOND · DECAD
Solar Total Energy Project, Shenandoah, Georgia
Solar One Project, Barstow, California


E · THE · BEGINNING
U.S. Steel Chemical Plant, Haverhill, Ohio

FOCUS · ON

SOLAR · THERMAL



The solar thermal industry is entering its second decade with dramatic increases in system effectiveness and use. Many solar thermal systems that provide environmentally clean, reliable, and affordable energy are now commercially available. Worldwide, the United States solar thermal industry is in a strong technological leadership position and is expanding sales in international markets.

The fundamental concept is simple: sunlight falling on a flat or parabolic-shaped mirror is concentrated and heats a working fluid (water, organic fluid, gas, liquid metal, or molten salt). The fluid is then used to deliver the thermal energy to the electric power generation system or industrial process. The thermal energy produced may also be stored to serve as a backup during weather interruptions, nighttime operations, scheduled maintenance, or emergencies.

The three types of solar thermal systems — parabolic troughs, central receivers, and parabolic dishes — are unique among alternative energy sources and complementary to conventional energy systems. Significant advantages and attributes include:

Variable temperatures and scale
Provides both thermal and electrical energy at almost any temperature and scale, from 200°F to over 2500°F, from tens of kilowatts to hundreds of megawatts.

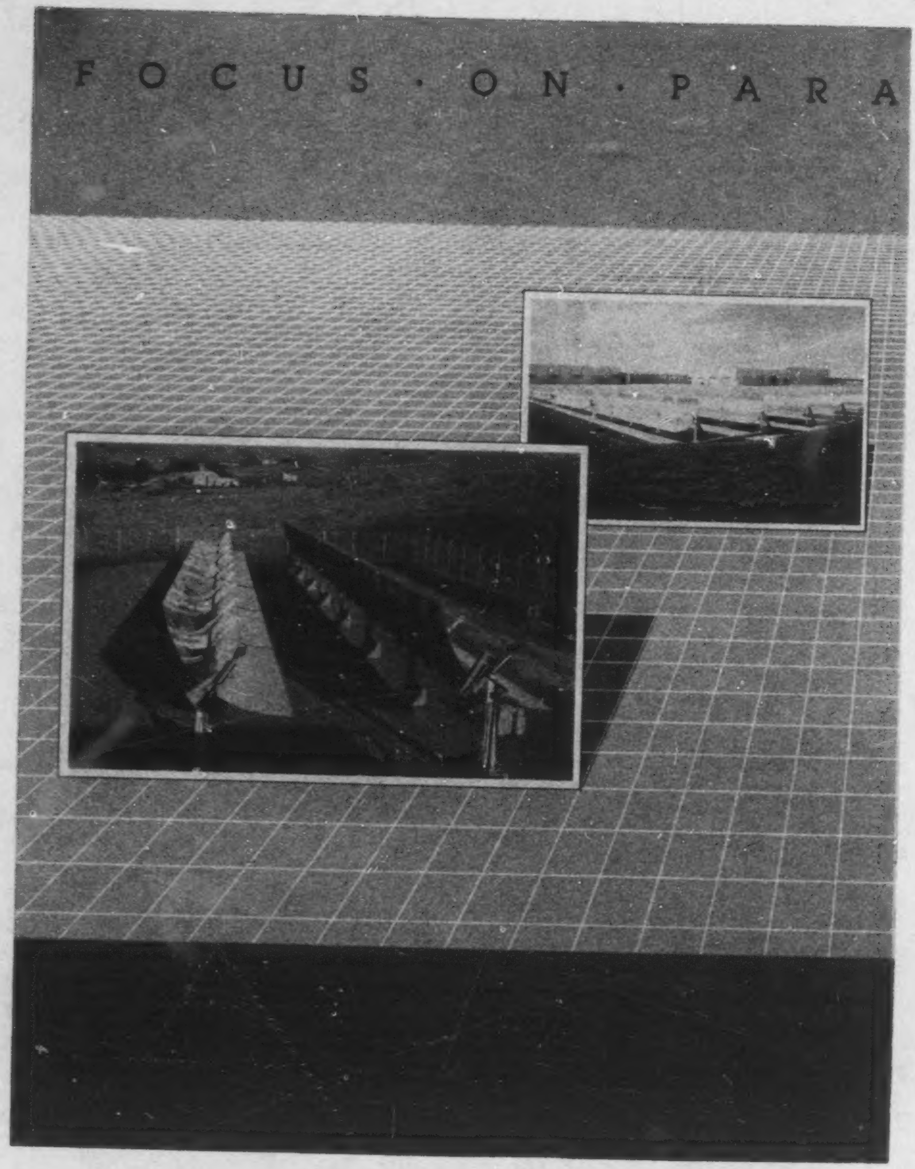
High efficiency and low cost direct conversion
Has the **highest** conversion **efficiency** (26% optical to electric, 80% solar to thermal) among the renewable technologies and is cost competitive with conventional energy systems for some applications.

Compatibility with conventional energy systems
Replaces or supplements conventional energy systems in existing plants.

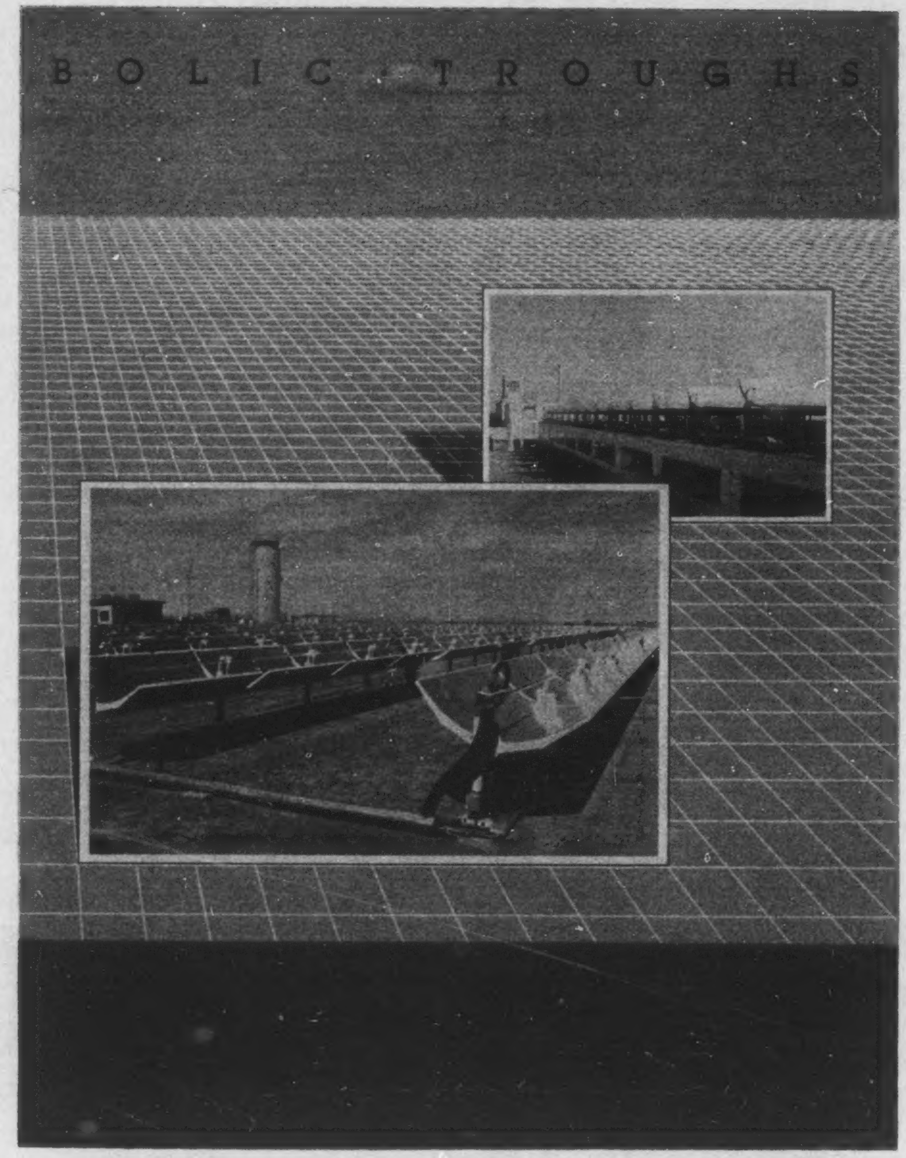
Direct high-temperature heat production
Provides high-temperature heat without a chemical, mechanical, or electric-to-thermal conversion step.

Continuous use
Is compatible with efficient and economical thermal energy storage systems which allow nearly continuous delivery of low-cost energy.

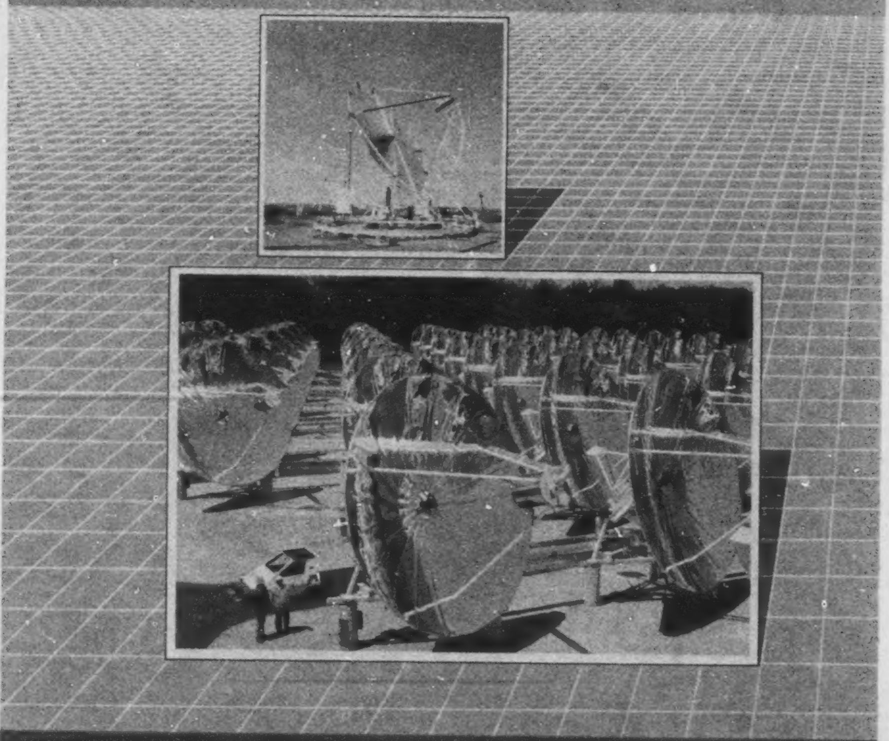
Solar thermal energy systems are now being used at sites across the Nation in applications spanning the energy utilization spectrum: utilities (electricity generation), industrial processes, and space heating and cooling. Most of the nation possesses sufficient solar resources to allow these systems to operate both effectively and efficiently. The widespread use of solar thermal energy systems will reduce our dependence on imported fuels thereby (1) reducing national vulnerability to changes in energy prices and availability, and (2) conserving domestic resources.



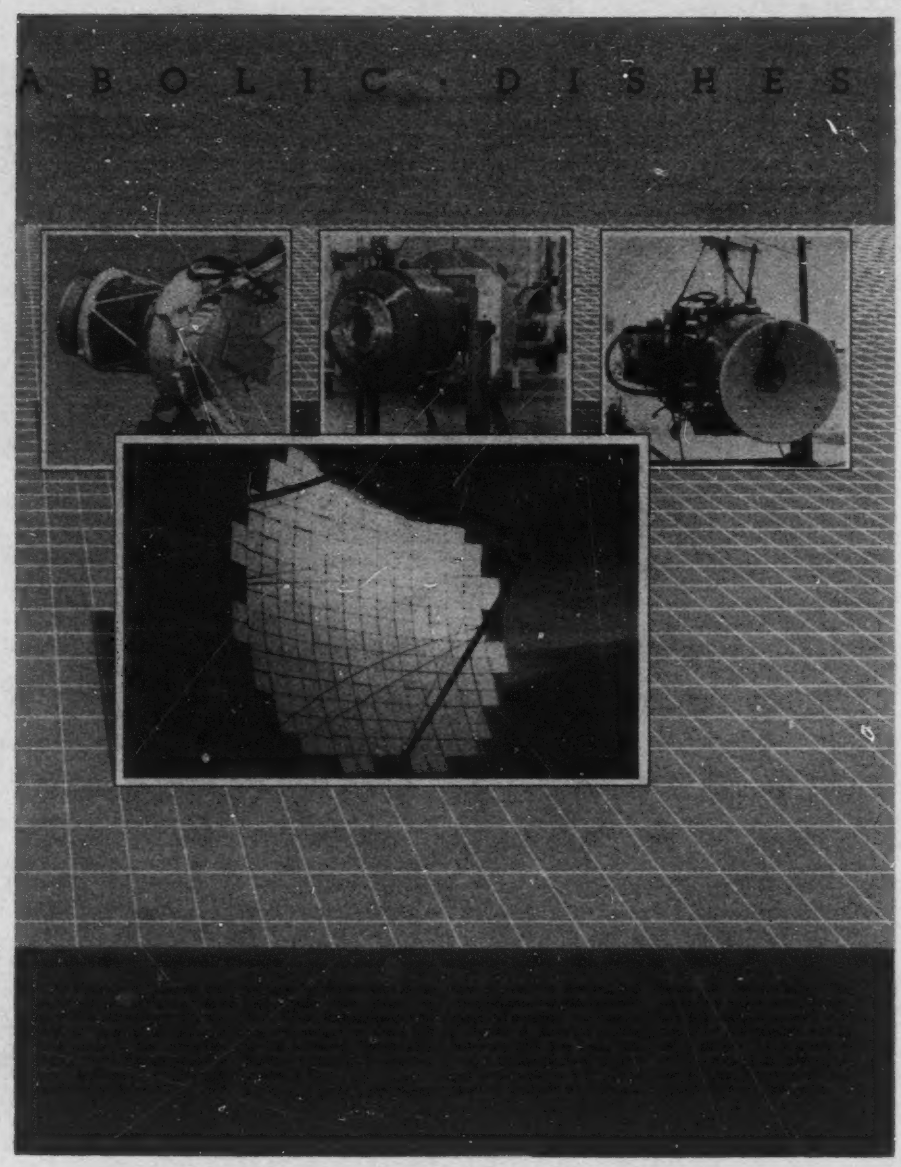
FOCUS · ON · PARA

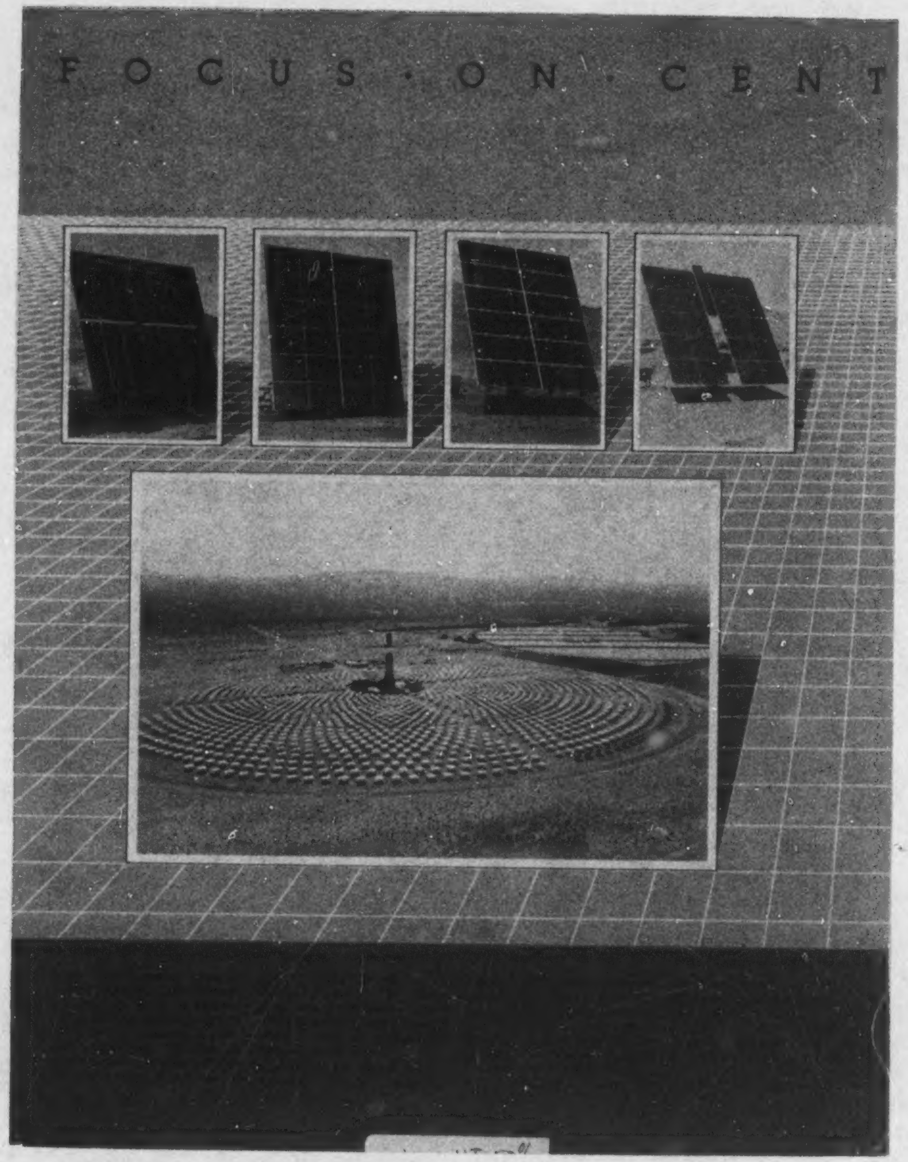

BOLIC TROUGHS

F O C U S · O N · P A R

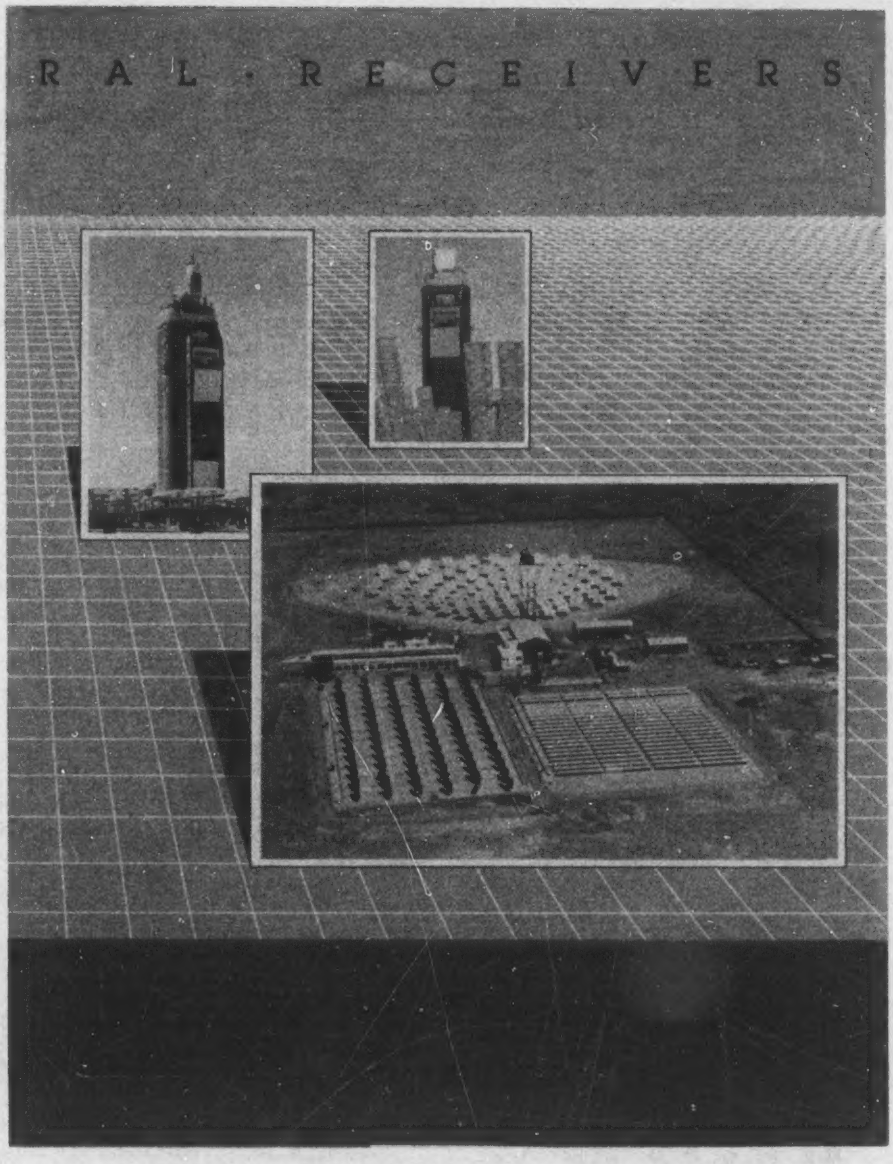


[illegible]

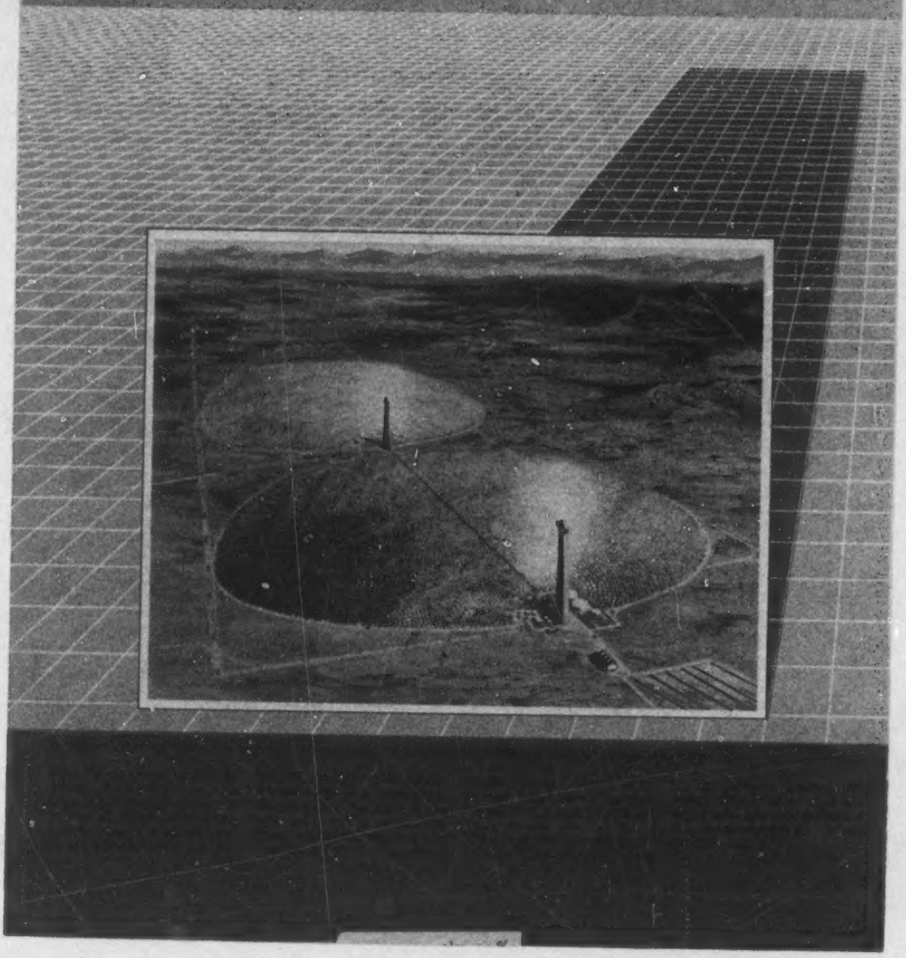

ABOLIC DISHES

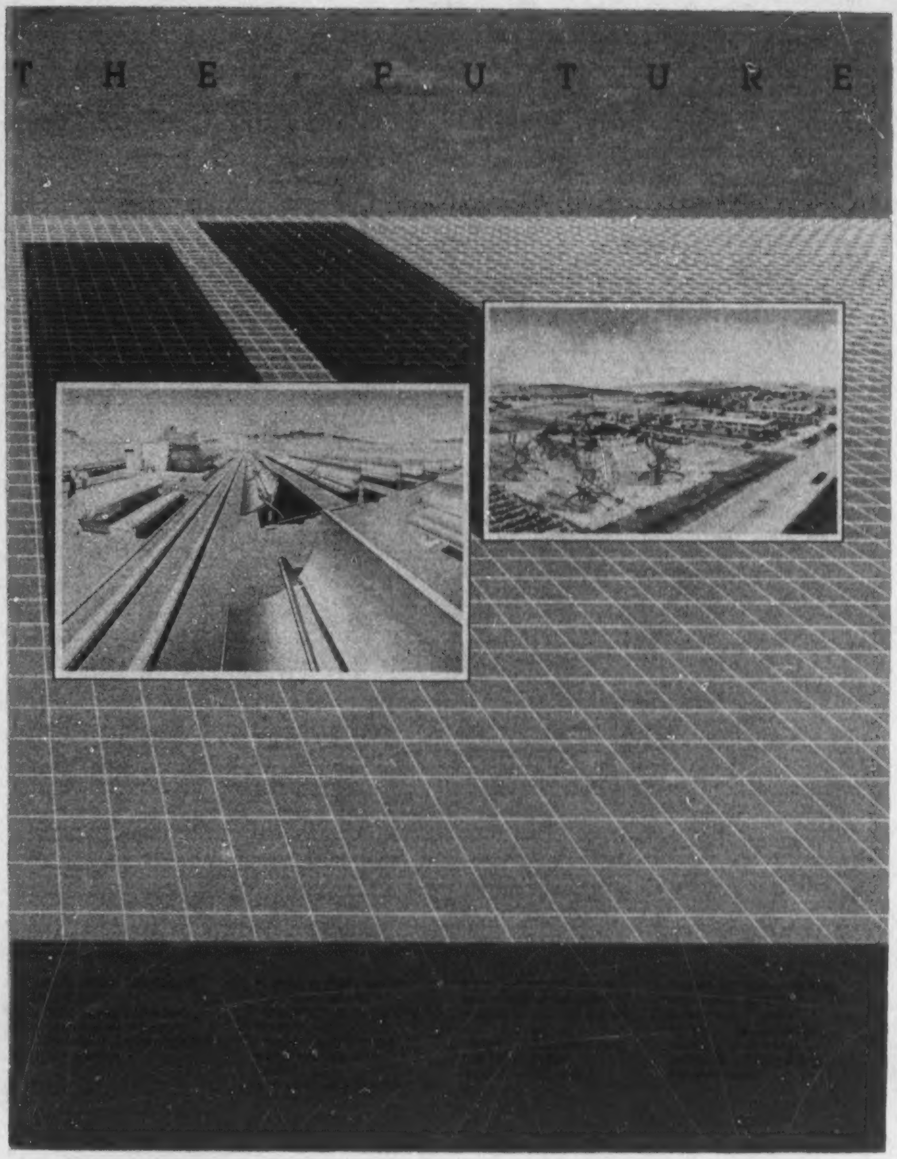


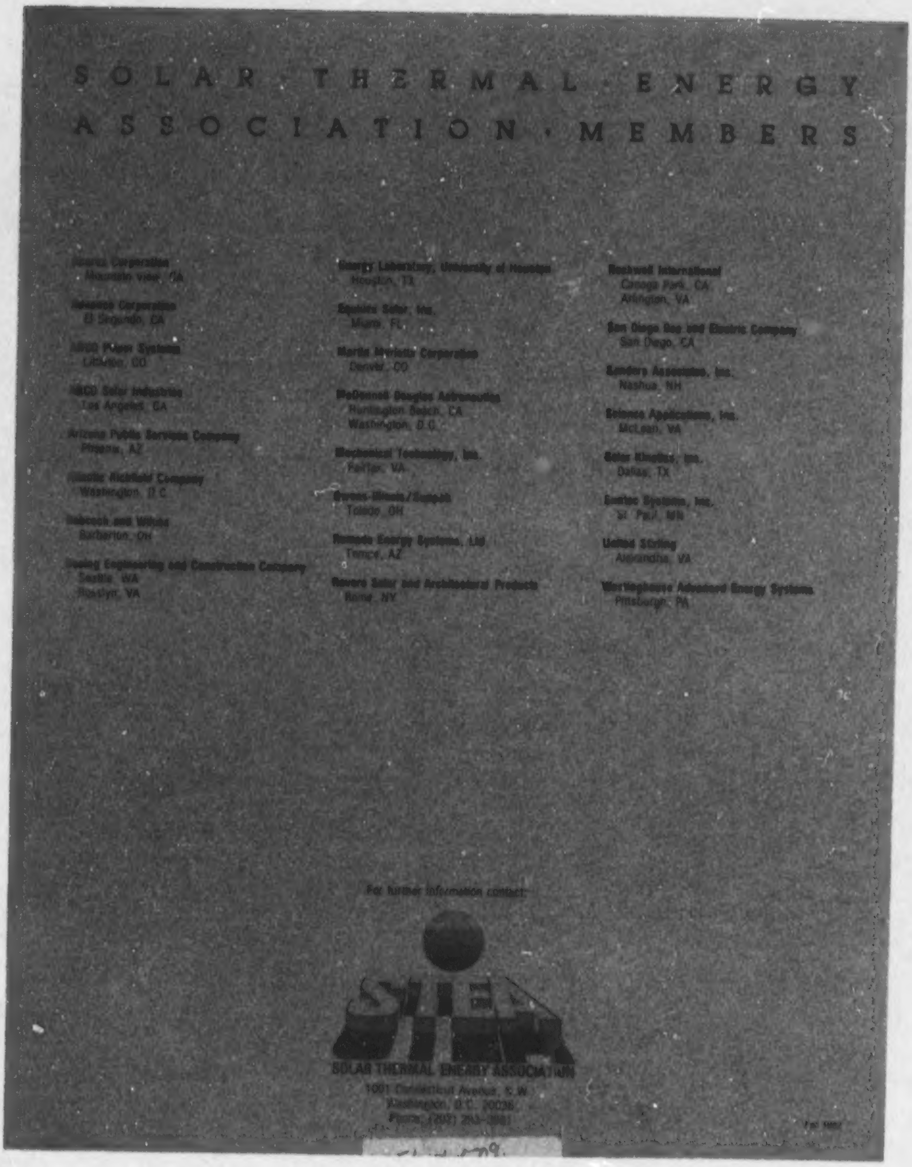
FOCUS · ON · CENT


RAL · RECEIVERS

FOCUS · ON ·




THE FUTURE



SOLAR THERMAL ENERGY ASSOCIATION MEMBERS

Acurex Corporation
Mountain View, CA

Aerospace Corporation
El Segundo, CA

ARCO Power Systems
Littleton, CO

ARCO Solar Industries
Los Angeles, CA

Arizona Public Services Company
Phoenix, AZ

Atlantic Richfield Company
Washington, D.C.

Babcock and Wilcox
Barberton, OH

Boeing Engineering and Construction Company
Seattle, WA
Rosslyn, VA

Energy Laboratory, University of Houston
Houston, TX

Equinox Solar, Inc.
Miami, FL

Martin Marietta Corporation
Denver, CO

McDonnell Douglas Astronautics
Huntington Beach, CA
Washington, D.C.

Mechanical Technology, Inc.
Fairfax, VA

Owens-Illinois/Sunpak
Toledo, OH

Ramada Energy Systems, Ltd
Tempe, AZ

Revere Solar and Architectural Products
Rome, NY

Rockwell International
Canoga Park, CA
Arlington, VA

San Diego Gas and Electric Company
San Diego, CA

Sanders Associates, Inc.
Nashua, NH

Science Applications, Inc.
McLean, VA

Solar Kinetics, Inc.
Dallas, TX

Suntec Systems, Inc.
St. Paul, MN

United Stirling
Alexandria, VA

Westinghouse Advanced Energy Systems
Pittsburgh, PA

For further information contact:

STEA
SOLAR THERMAL ENERGY ASSOCIATION
1001 Connecticut Avenue, N.W.
Washington, D.C. 20036
Phone: (202) [illegible]

APPENDIX B
(PAGES 38-48)

SOLAR ENERGY RESEARCH AND DEVELOPMENT:

FEDERAL AND PRIVATE SECTOR ROLES

REPORT OF THE ENERGY RESEARCH ADVISORY BOARD

Prepared by the

SOLAR R&D PANEL

September 1982

V. SOLAR THERMAL

A. Critical R&D Issues

1. Introduction

Solar thermal energy systems convert the sun's radiant energy to heat energy. The heat may then be used directly for industrial applications or to generate electricity. A unique feature of the solar resource is the ability to use radiant energy to produce high temperatures. Temperatures up to 1370°C can be achieved. To date, a 20% net conversion efficiency of sunlight in to electricity out has been achieved at the Solar One Central Receiver Plant. A net efficiency of 26% has been attained with a Parabolic Dish/Stirling Engine system.

Solar thermal covers five different technologies. These exhibit varying degrees of technical maturity and acceptance in the marketplace. With the exception of solar ponds, the solar thermal technologies concentrate solar energy to various degrees, sufficient to achieve higher efficiencies for the production of industrial process heat, electricity, and fuels.

2. Parabolic Troughs

Parabolic troughs are the solar thermal technology with which there has been the most experience. A number of systems are in operation. More than three-quarters of a million square feet of collectors have been installed as a result of field test experiments, research and development projects, and commercial sales. In successive projects, parabolic trough systems have demonstrated increasingly higher efficiencies, higher reliability and lower costs.

3. Central Receivers

Solar thermal central receiver technology is a near-commercial solar energy option for electric power production for utility systems. If the current momentum in this technology can be maintained, commercial application of central receivers can begin during the next few years. However, it is at this point—the demonstration stage—that some specific government involvement is most critical to ensure a successful transfer of technology to the risk-adverse utility industry.

The best evidence of the status of development of solar central receiver technology is seen at the 10 MW "Solar One" pilot plant near Barstow, California. Operation began on April 12, 1982, with initial power production to the Southern California Edison electric grid. After a three to four month start-up period, a five-year test program will begin this year. The first two years of operation will include experimental testing of the major subsystems and evaluation of operation, maintenance requirements and costs. This period will be followed by power production tests to obtain longer term operation, maintenance, reliability, and cost data.

In addition to Solar One, five other similar, but smaller (1/2 to 2MW), government sponsored central receiver pilot plants are starting up in Western Europe (Spain, France and Italy) and Japan. These pilot projects serve as laboratory facilities to provide information and firsthand experience with the operation and maintenance of this new technology. Various industrial concerns are currently considering even larger installations. Utilities and equipment manufacturers are watching and monitoring progress to more accurately assess performance and cost for the next installation, perhaps in the 30-100 MW range.

Extensive component testing has also occurred in the U.S. in recent years. Four different receiver concepts using different heat transfer fluids--air, water, salt, and sodium (the latter at private expense)--have been tested and show encouraging results. Also, four complete second generation heliostat systems have been tested.

Results from these prototype tests and studies have demonstrated that commercial scale production of sun-tracking heliostats is feasible and can be economically attractive in large quantity production. There appears to be no insurmountable technical barrier to the successful development of central receiver systems.

4. Parabolic Dishes

Parabolic dish concentrators provide two-axis tracking of the sun for high collector efficiency coupled with highly efficient heat engines. Each concentrator/engine unit or module can independently produce thermal and electrical energy. This technology represents a particularly promising technology for a diverse market ranging from small isolated loads to multi-megawatt grid-connected systems. Recent tests using Stirling and organic Rankine engines established technical feasibility and sunlight conversion efficiencies in excess of 26%. The modularity of these 20 to 25 KWe units, as well as a short lead time for construction, provide favorable flexibility in load planning and financing of new electric generating capacity.

The technology is new. Considerable generic research remains to be done, particularly in the areas of reflective and ceramic materials, non-gaseous fueled hybrid receivers to increase capacity factors, system level controls, and alternative concentrator design. Small, multi-unit prototype projects will be required to develop proof that parabolic dish systems for electricity production can interact on an autonomous basis. The cost of such a program is relatively small and cost sharing should be encouraged.

5. Hemispherical Bowls

A 65-foot hemispherical bowl is operating in Crosbyton, Texas, and there is interest in expanding the concept to one or ten 200-meter hemispherical bowls to operate in conjunction with a new fossil fuel power plant. Cost for the power plant and one hemispherical bowl is estimated to be $10.6 million. The cost for the power plant and ten bowls is between $28 and $31 million. The remaining critical R&D issue primarily lies with low annual collection efficiency, high thermal losses, and the scaling up of the prototype design to 200 meters. However, the Panel is concerned about the comparatively low average annual collection efficiency of this technology, the thermal losses associated with the long piping of the collected thermal energy and the appropriateness of DOE funding all or part of the cost for the fossil fuel portion of the proposed demonstration plant.

6. Solar Ponds

Solar pond technology for both heat and electricity production is still in the developmental stage. It holds some promise for commercial use in those regions of the nation where huge amounts of saline water and flat, open terrain are readily available. This technology is currently being demonstrated in a two-acre pond at Ein-Bokek in Israel, generating 150 KW of electricity. The construction of a 10-acre, 5 MW pond at the Dead Sea in Israel is 60% complete, and the pond is scheduled to be in operation in 1983.

Development of the solar pond technology in the United States is confined to laboratory tests and feasibility studies. With support from the Department of Energy, Southern California Edison and the California Energy Commission conducted a 5 MW Salton Sea feasibility study. The Jet Propulsion Laboratory and the Army Corps of Engineers have also conducted tests on pond characteristics. A number of major site-related pond technology questions, such as maintenance of water clarity, local brine production, permeability of pond bottoms, questions relating to wind suppresion, and salt gradient stability, maintenance of the salinity and thermal stratification, and environmental protection remain to be resolved. On the conversion-plant technological front, brine removal and return, brine nozzles, heat exchanger and efficiency improvements remain to be resolved. On a site specific basis, solar ponds may offer a productive use of brines generated from desalinization plants.

To supplement Israeli experience, to address site specific characteristics and to evaluate different environmental and operating requirements, the Panel has considered the importance and feasibility of the United States developing its own technical base for this application. The progress of solar salt pond technology, from a few megawatt proof-of-concept pilot plant to full fledged commercial plants of tens-to-hundreds of megawatts would require successful experimental plant tests in perhaps two locations. At the same time, site specific pond-related studies and tests at various resource locations would have to be done to be followed by commercial installations based on experience and data.

7. Fuels Production Using Solar Thermal Technologies

Finally, there is the technical possibility of using solar thermal processes to derive fuels and chemicals. Solar thermal energy systems can be used to produce, efficiently and economically, a variety of fuels and chemicals—

including hydrogen. Solar is capable of driving high temperature (greater than 2000°F), thermo-chemical reactions, high flux (greater than 1MWe/M), non equilibrium reactions and direct photon driven processes. Solar thermal systems can provide a combination of temperature and flux not achievable through conventional process design, which can significantly enhance efficiency and result in higher value products.

8. Technology Base R&D

A number of critical R&D areas have promise for providing the technology base necessary for the next generation of solar thermal technologies including improved central receiver, dish and trough systems, with considerably improved performance and reduced energy costs. These include:

-- The development of new materials with good optical qualities and long life

-- The development of lightweight, low cost concentrating structures

-- The development of high temperature materials

-- Research into the use of thermal processes for fuels production which should be coordinated with similar activities in the biomass energy area.

Environmental issues related to solar collectors include land use (6-8 acres per megawatt for central receivers and parabolic dishes), esthetics in some cases, and, in a few cases, bird and insect mortality.

B. State of the Industry

There is a diverse cross section of American industry in solar thermal technologies, ranging from the small high technology firms to the large aerospace and petroleum companies. Fifty-seven companies represent the nucleus of the industry. The majority of larger firms are engaged in central receiver technology. The larger companies can be characterized generally as risk averse, while the smaller companies have limited economic strength.

Most of these companies are seeking sales of their first generation hardware by capitalizing on the Federal and State energy tax credits to help obtain financing; many depend upon venture capital. Two recent announcements by the parabolic trough industry of purchase power agreements with Southern California Edison (SCE) provide an indication that these systems may be on the verge of becoming commercial. However, recent market uncertainties and general economic conditions may hinder commercialization of this technology at this time. The central receiver industry is bidding on both the design phase of a DOE Program Opportunity Notice and a Notice of Program Interest from SCE that will provide the detailed design effort and market pull for near-term implementation.

In summary, the parabolic dish, hemispherical bowl and salt ponds are not yet ready for first generation commercial sales.

C. Transfer of Federal R&D

The DOE Solar Thermal Program has had close and continuing coordination with the developing industries in each of the technology areas. Approximately 75% of its R&D funds were spent through industry and, thereby, ensured an early development of personnel, expertise, and hardware transfer. DOE test facilities are used by industry for trough testing. The program has held annual technical review meetings and many topical symposia and workshops.

A number of factors inhibit rapid industrial investment in solar thermal technologies which otherwise are rapidly nearing commercial status. These include: a difficult investment climate and high interest rates, the added risk of a new technology without a long record of performance, and a complicated regulatory framework. To these inhibitors is added the uncertainty about the continuation of the Federal energy tax credits. These points are discussed in detail in Chapter X as common problems for many emerging solar technologies.

D. Recommended Federal and Private Sector Roles and Objectives

1. Parabolic Troughs

The parabolic trough technology is commercially available and requires only a low order of continued DOE support in materials research (including environmental testing) and operational testing of key demonstration projects to complete the technology transfer process.

There appears to be a minimal role for DOE after the completion of the FY 82 funded Modular Industrial Solar Retrofit (MISR) design and testing effort. Thereafter, the R&D critical issues are directly associated with the generic need for low cost, long life reflective surfaces, and receiver materials of high absorbtance and long life. Operation of a select number of DOE sponsored demonstration projects should be continued for gathering data to resolve these R&D issues and transfer of the technology to industry.

2. Central Receivers

The paramount requirement of the Federal solar thermal central receiver program over the coming years is to ensure that the Solar One experiment is carried through to a logical and thoroughly understood conclusion. Success in this activity will require completion of the plant's automatic control system, extensive operation coupled with thorough evaluation of the plant's performance and operating requirements, and dissemination of test data and operating experience to all interested parties. In defining the remainder of the Solar One program, the overall aim must be to maximize the benefit to the country of the extensive public expenditure to date, rather than to seek an expedient path for completing the experiment at minimum incremental cost. The outcome of the Solar One experience will have far greater bearing on any subsequent initiatives in solar thermal central receiver systems than any other single activity.

In addition, the DOE should cost share with industry on programs that will prove advanced receiver and thermal storage concepts. One such test, which is being organized under EPRI auspices, is the Molten Salt Electric Experiment at the Central Receiver Test Facility (CRTF) in Albuquerque, New Mexico.

The private sector is actively pursuing various avenues to move the technology out of the demonstration phase. For example, the recently issued Solar Program Opportunity Announcement by the Southern California Edison Company for the construction of a pre-commercial plant* by 1988 is seen as a critical first step to commercialization. However, these efforts by the private sector assume continued Federal support, including operation of Solar One, system and component develoment and tests at CRTF, cost-shared support for repowering, and the extension of the business energy tax credit beyond 1985.

3. Parabolic dish

The DOE should redirect its emphasis to the parabolic dish program for further technology development because of its potentially higher efficiencies and lower costs. Future component research should concentrate on areas that will either significantly improve known efficiencies, extend the useful life, or reduce the capital and operating costs of the modules. Small multi-module experiments should be programmed on a cost-sharing basis. The ability of the parabolic dish program to pursue three heat engine options needs to be evaluated in relation to the long-term market requirements and the availability of complementary Federal funds in the automotive engine R&D programs.

---

*A pre-commercial plant is defined as a custom-made, first-of-a-kind facility whose components are not yet in commercial production.

4. Hemispherical Bowl

Hemispherical bowl technology, specifically the Crosbyton Project, has had $4.0 million in FY 82 appropriated from the Solar Reserve Fund. Continued funding of this project in FY 83 and beyond would be undesirable, especially considering the Panel's overall recommendation against large scale demonstration projects. The inherently low average annual collection efficiencies, high thermal piping losses and a rather isolated market pull, discourage further R&D support for hemispherical bowl technology.

5. Solar Ponds

The Panel is not convinced of the prospects for solar pond technology. In view of the foreign leadership in solar pond technology the Panel recommends the maintenance of only a small technical staff to monitor progress in this field. Should DOE find it appropriate, specific research and development may be warranted in the future.

6. Demonstration Projects

No new large scale demonstration projects can be advocated under the present budgetary constraints. The only role for the DOE would be to provide data acquisition equipment and data reduction costs in order to improve technology transfer throughout the industry.

7. Technology Base R&D

The DOE basic and applied research program for solar thermal must achieve a sharper focus based on anticipated availability of first generation technology. Priority should be given to optical, thermal and structural materials; the sciences of thermodynamics, heat and mass transfer; and fuels production.

Many of these research areas will produce results useful to all the solar thermal technologies.

The Federal role should be to coordinate generic research needs in all the solar thermal areas. These include reflective and ceramic materials, operation of vital systems level experiments for technology transfer, and participation in the second generation of component development.

8. Summary of Private Sector Roles

The parabolic trough industry has indicated the existence of entrepreneurial interests in marketing its first generation systems for both industrial process heat and electrical applications, provided private financing can be obtained. The private sector will provide the system level engineering required for large scale sales. The central receiver industry is similarly pursuing first generation sales but there is a far greater need to rely on development of future components, volume sale of heliostats, and continuation of the energy tax credit. The parabolic dish industry will be required to perform R&D and engage in small, system level experiments on a cost-sharing basis before first generation technology will be ready for the marketplace. The hemispherical bowl and salt pond technologies do not appear to have an industrial participant that would undertake, on a cost-sharing basis, the technical and economic risks of the proposed demonstration projects.

Mr. **Fuqua**. Thank you very much, Mr. Washom.

Mr. Tharpe.

STATEMENT OF B. J. THARPE, GENERAL MANAGER, ADVANCED ENERGY PROGRAMS DEPARTMENT, GENERAL ELECTRIC CO.

Mr. **Tharpe**. Mr. Chairman and members of the committee, my name is Bob Tharpe. I am general manager of the advanced energy programs department of General Electric Co.

My testimony is available to you there, and I will only excerpt a few key statements about my company's efforts on the MOD-5 wind turbine generator program. I will then make myself available for any questions that you may have, with your permission.

Several significant improvements have been made in the design, as described in your material. In obtaining industry participation in the hardware phase, we have structured a program in which industry will assume the responsibility and the cost for the entire hardware phase of the MOD-5A wind turbine program. We are in the process now of obtaining the necessary commitments for that.

This arrangement is responsive to the direction of both Congress and DOE and assumes that the Government will fulfill its role of completing the design, development, and checkout of the MOD-5 prototype.

Industry, for our part, will complete the hardware fabrication and the installation and will perform the operational demonstration.

The GE-industry team will consist of, No. 1, several customers who will purchase the machine from GE at a discounted price, provide the site and the grid interconnect, and operate the machine.

No. 2, Electrical Power Research Institute will gather, evaluate, and promulgate operational data as well as sponsor technology improvements to the machines.

No. 3, General Electric will manage the project, perform the work, and provide operational support for an extended 5-year field demonstration.

We think this program will allow the Nation to reap the benefits of the extensive wind energy program conducted by the Federal Government.

Additionally, the overall program plan provides for an expanded prototype phase demonstration of up to three MOD-5A prototypes. It is anticipated that the machines will be sold to three different customers and therefore deployed in three different locations. This will subject the machines to a variety of operational and environmental conditions.

The total cost of this plan will be about $90 million, with industry assuming by far the largest share of the cost, nearly $60 million.

We in General Electric have made a significant commitment to continue the MOD-5A wind turbine program. We have several potential customers who are already spending large sums in anticipation of purchasing one of the three MOD-5 prototypes. These customers are willing to take significant risks, even recognizing the early and prototype character of these machines.

We are confident that the Congress and the administration will continue to see the great value in this joint industry and Government completion of the MOD-5 program and will therefore continue the effort to a successful conclusion.

That is the end of my summary excerpts. If you have any questions, Mr. Chairman, I will be happy to answer them.

[The prepared statement of Mr. Tharpe follows:]

TESTIMONY PRESENTED BY

B. J. THARPE, GENERAL MANAGER
ADVANCED ENERGY PROGRAMS DEPARTMENT
GENERAL ELECTRIC COMPANY

TO
98th CONGRESS
HOUSE COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS

MARCH 15, 1983

Mister Chairman, members of the committee, my name is Bob Tharpe. I am General Manager of the Advanced Energy Programs Department of the General Electric Company. It is my pleasure to discuss with you today the status of my company's efforts with respect to the MOD-5A Wind Turbine Generator Program.

During the past year, we at General Electric have concentrated on the continuation of the engineering design and development of the MOD-5A wind turbine generator and on rearranging the MOD-5 Program structure to be consistent with the guidance provided by this committee in their 1982 budget message.

The MOD-5A development program continues to progress in a satisfactory manner with the engineering design and development testing activity well underway. Several significant improvements have been made to the design (Figure 1) since our last report including:

1) Machine rating has been upgraded from 6.2 MW to 7.3 MW.
2) A variable speed generator has been included in the drive system. This change provides added assurance of safe and reliable operation.
3) Single point major failure modes are, wherever possible, being eliminated from the system. If this is not possible, then we are increasing the design margins. This is in recognition of the recent operational experiences of the MOD-2 project.
4) The development and qualification test programs have been expanded to provide additional design data and to verify fabrication processes prior to operation of the machines in a field environment.

We are taking a very cautious approach to completing the development effort which takes more time and additional effort; however, this will enhance the probability of success and reduce the time and effort that will be expended when the machines are placed in a user operational mode. The reduction of risk in this manner has been quite well received by the potential customers for the MOD-5A prototypes.

With respect to obtaining industry participation in the hardware phase, we have structured a program in which industry would assume the responsibility and cost for the entire hardware phase of the program and are in the process of obtaining the necessary commitments. This arrangement is responsive to the direction of both Congress and DOE and assumes the government will fulfill its role of completing the design, development and checkout of the MOD-5A prototype. Industry, for its part, will complete the hardware fabrication and installation, and will perform the operational demonstration. (See Figure 2) The GE/industry team will consist of: (1) the customer, who will purchase the machine from GE at a discounted price, provide the site and the grid interconnect and operate the machine; (2) the Electric Power Research Institute who will gather, evaluate and promulgate operational data as well as sponsor technology improvements; and (3) General Electric, who will manage the project, perform the work and provide operational support for an extended five year field demonstration. This program will allow the nation to reap the benefits of the extensive Wind Energy Program conducted by the Federal Government.

Additionally, the overall program plan provides for an expanded prototype phase demonstration of up to three MOD-5A prototypes. (See Figure 3) The three prototypes will be time-phased to provide backup hardware for the preceding machines but spaced at an interval where changes made as a result of operational experience can still be factored into the succeeding machines. It is anticipated that the machines will be sold to three different customers and, therefore, be deployed in three different locations. This will subject the machines to a variety of environmental and operational conditions. The total cost of this plan would be nearly $90.0M with industry assuming by far the larger share of the cost, nearly $60.0M.

Of significant concern to each customer is: (1) what assurance is there that the government will complete their part of the program? and (2) what assurance is there that the tax incentives will be continued, to allow further purchases of wind turbines. Our response to the first question has been to commend the record of this committee and its continued commitment to the satisfactory completion of the large horizontal axis wind turbine generator program. We were distressed recently to learn that DOE had been considering a deferral, to withhold 1983 funds from the MOD-5 program. This step would have been particularly unreasonable, when, in accordance with congressional guidance and understandings with DOE and NASA, industry is already expending its funds to help complete the project successfully. On the second issue of tax credits, we cannot provide any assurances, as that is the province of the Administration and Congress.

With increased experience and production, wind turbine costs are expected to decrease to a point where direct purchase by utilities would be economically feasible in areas of premium winds and high fuel costs, even with no escalation of fuel costs in real dollars. (See Figure 4)

As production costs continue to decrease, purchase of the machines will become economical, even in areas of lesser winds and more moderate fuel costs, opening up the potential market for large numbers of wind turbines in those areas of the country where there is a significant wind resource. Wind energy could then make a meaningful contribution to our nation's energy needs.

We in General Electric have made a significant commitment to continue the MOD-5A Wind Turbine Generator Program. We have several potential customers who are already spending large sums in anticipation of purchasing one of the three MOD-5A prototypes. These customers are willing to take significant risks even recognizing the early, prototype character of the machines. We are confident that the Congress and the Administration will continue to see the great value in the joint industry/government completion of the MOD-5 program and will therefore continue the effort to a successful conclusion.

TECHNOLOGY IMPROVEMENTS IN MOD-5A PROGRAM

FEATURE	MAJOR BENEFIT
SYSTEM SIZE	
• SIGNIFICANT SCALE-UP FROM PRESENT TECHNOLOGY	• LARGE REDUCTION IN COST OF ENERGY • LESS LAND INTENSIVE, MORE EFFICIENT FOR OPERATION AND MAINTENANCE
ROTOR	
• WOOD LAMINATE BLADES (MULTIMEGAWATT APPLICATION)	• REDUCES SYSTEM COST AND WEIGHT
• NON-ROTATING SUPPORT	• MINIMIZES FATIGUE LOADING ON LOW SPEED SHAFT
• HIGH EFFICIENCY ROTOR AIRFOIL SECTION	• IMPROVES ENERGY CAPTURE
GEARBOX	
• HYBRID EPICYCLIC/PARALLEL SHAFT SHAFT DESIGN	• HIGH TORQUE CAPABILITY AT INPUT, LOW COST AT HIGH SPEED END
GENERATOR	
• VARIABLE SPEED/CONSTANT FREQUENCY	• REDUCES SHOCK LOADING ON DRIVE TRAIN • INCREASES ENERGY CAPTURE
YAW DRIVE	
• PUSH-PULL, HYDRAULIC SYSTEM	• PROVIDES ACTIVE YAW CONTROL AT LOW COST, WITH HIGH RELIABILITY

FIGURE 1

ROLES OF PARTICIPANTS IN MOD-5A PROGRAM

	NASA-DOE	GE	USER	EPRI
FUNDS	• DESIGN, DEVELOPMENT AND FIELD SHAKEDOWN • DATA ACQUISITION	• PROTOTYPE HARDWARE COST IN EXCESS OF SALE PRICE • FIX/REPAIR AND SUPPORT FOR 5 YEARS	• MOD-5A PRICE • USER FURNISHED ITEMS	• FIELD QUALIFICATION • SYSTEM MONITORING, DATA ANALYSIS & REPORTS • EVALUATION OF ADVANCED FEATURES • SYSTEM UPGRADE-MODIFICATIONS
PERFORMS	• PROGRAM REVIEWS • DESIGN REVIEWS • DATA ACQUISITION SYSTEM PROCUREMENT • OPERATIONAL DATA REDUCTION	• DESIGN, DEVELOPMENT AND FABRICATION • INSTALLATION AND CHECKOUT OF WTG • CUSTOMER TRAINING • FIX/REPAIR AND OPERATIONAL SUPPORT FOR 5-YEAR PERIOD	• PROJECT MANAGEMENT • SITE ACQUISITION • SITE PREPARATION • GRID INTERCONNECTION • O&M	• DESIGN REVIEWS • INFORMATION DISSEMINATION TO UTILITY INDUSTRY

FIGURE 2

MOD-5A PROGRAM MASTER SCHEDULE - 3 PROTOTYPE UNITS

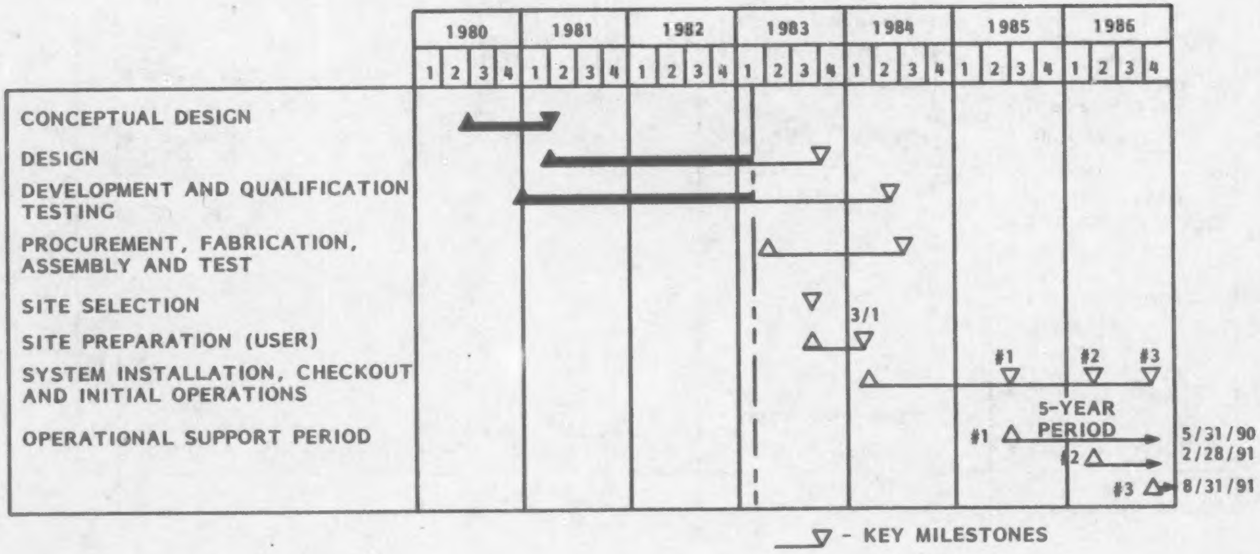


FIGURE 3

PROJECTED WIND TURBINE ECONOMICS (UTILITY PURCHASES)

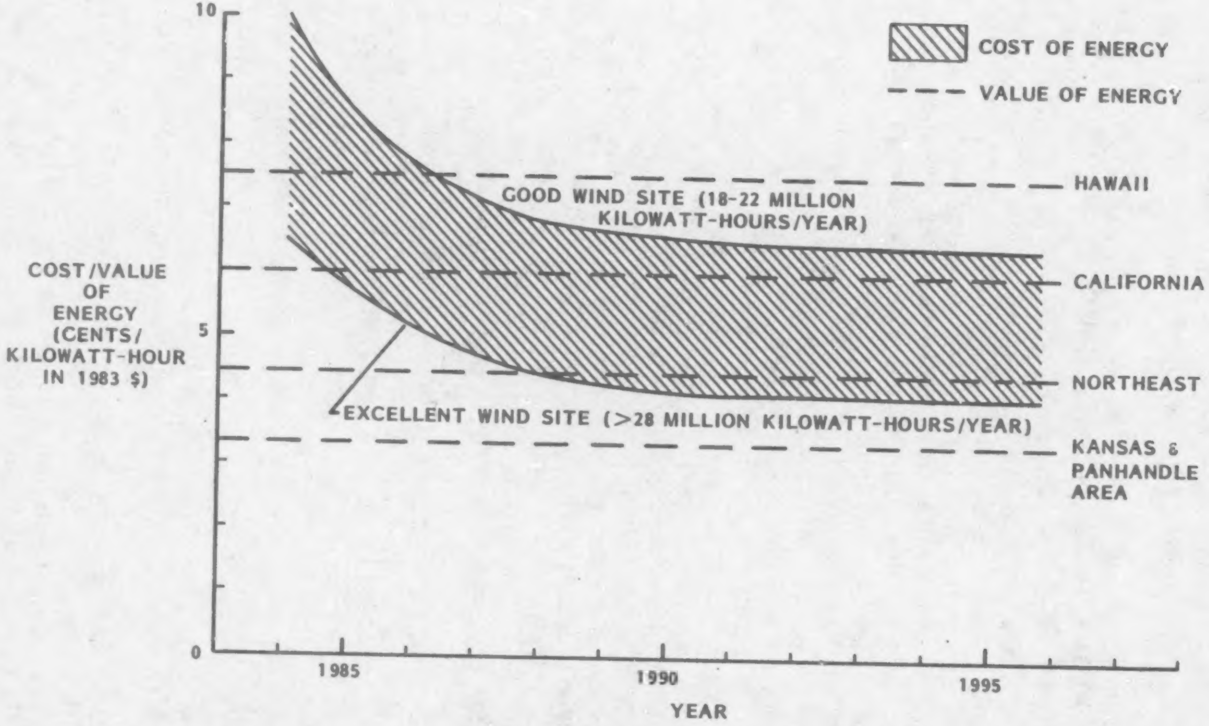


FIGURE 4

Mr. **Fuqua**. Thank you.

Yes, we will have some questions in a few moments.

We will now hear from Mr. Jackson.

STATEMENT OF ARTHUR JACKSON, DIRECTOR, WIND ENERGY SYSTEMS, HAMILTON STANDARD DIVISION, UNITED TECHNOLOGIES CORP.

Mr. **Jackson**. Mr. Chairman and members of this committee, I am Art Jackson, director of Wind Energy Systems at Hamilton Standard Division of United Technologies Corp.

We are pleased once more to be given an opportunity to discuss our views on the status of wind energy and possible future Federal involvement in this field.

Much has happened in the last year of importance to the long-term development of wind energy as a substantial source of electricity for our Nation's utilities.

In general, the marketplace problems identified in my statement submitted to this committee last year have become, if anything, even more severe, and there also have been twists in the path of industry development that we did not fully foresee.

These events have forced us to conclude that if wind energy is to become a major power generation option in a foreseeable time period, further action by the Federal Government in assisting commercialization is now of critical importance. I will comment more specifically regarding this matter, but first a brief report is in order regarding the status of the wind energy effort at Hamilton Standard.

During the summer and fall of 1982, we completed construction of the world's two most powerful wind turbines, one a 3-megawatt machine located in Maglarp, Sweden, and the other a 4-megawatt unit in Medicine Bow, Wyo. There are attached to this statement photographs of these two machines. I also had some colored slides, but I guess we are not going to have the benefit of looking at those this afternoon.

Mr. **Fuqua**. There seems to be a power outage.

Mr. **Jackson**. Yes, one of those.

Mr. **Fuqua**. I understand we have the power but no light. Perhaps we can correct that later on.

Mr. **Jackson**. In both instances, we worked in close association with a large Swedish firm, Swedyards, a specialist in advanced ship construction techniques, who was responsible for wind turbine nacelle detail design and fabrication, with, in each instance, Hamilton Standard retaining overall system design responsibility.

The Swedish machine was constructed under the auspices of, and with funding from, the Swedish Government, while the Wyoming machine was procured by the U.S. Department of Interior's Bureau of Reclamation.

Basic development work on both units was performed at contractor expense. Both machines embody the most advanced technology available anywhere in the world today—that is, composite blades, sophisticated control electronics, active/passive load alleviation, et cetera—and their ultimate cost effectiveness in derivative, serialized production configurations, in comparison to conventional fossil fuel power production technologies, still is predicted to be favorable, despite current turbulence in the oil markets.

Operations of both machines since startup have produced extremely gratifying engineering results. Power production under various wind conditions has been excellent; in fact, it has been somewhat better than forecast.

With the Wyoming unit, we have also attained sustained power production at an overrating condition of 4.8 megawatts, thus confirming the feasibility of much of the potential energy production growth—5- to 6-megawatt ratings with extended rotors—which we expect the equipment to handle down the road.

During initial runs, substantiation of the expected dynamic structural behavior of all major machine components was realized, allowing unrestricted, stable operation at all points on the power curve.

As those who read my last year's statement will recall, it is our firm conviction that success of large-scale machines will be based largely on the contractor's ability during initial design to predict accurately the lives of major components. Trial and error fixes of operational problems, an acceptable development technique with smaller units, would be prohibitively expensive, as experiences with both MOD-1 and MOD-2 machines have demonstrated.

The foundation of accurate predictions must be the contractor's skill in closely matching measured loads and response with predicted loads and response for all major structural components.

Agreement with prediction, as seen in exhibit 2, which is attached to this statement, is exceptionally good. The margins needed for the higher loads of an increased energy-producing machine, to be derived from our prototypes, have been clearly confirmed.

Technically, we have established the capability to move in the direction of a growth machine immediately and are well along with such an effort. Meanwhile, on both prototypes, we are proceeding to clean up all significant maintenance conditions so that standard utility hands-off operation can be sustained. One machine has received customer acceptance already, and acceptance of the other is expected momentarily.

Long ago, we recognized that when this stage of hardware development was reached, it would be unlikely that interest in wind energy on the part of the intended long-term customers—that is, medium-size and large U.S. utilities—would have matured to a level sufficient for the direct support of serialized production of units such as ours, regardless of their attractive predicted economics.

The problem, of course, is proof of equipment reliability. No utility that we know of is in a position to undertake, without Public Utility Commission support, the financing of multiple-unit proof-of-reliability projects on the scale necessary to put to rest existing major uncertainties regarding unit availabilities and system operating costs.

With the mixed success of existing large machine prototype projects, such PUC support is not likely to be available for some time, nor do we believe that utilities will soon seek it.

Clearly, equipment manufacturers are not in a position to generate the funds internally for the multiple projects required, nor do

DOE-sponsored demonstration projects of the type envisioned in the 1980 National Wind Energy Act any longer appear feasible.

The future of wind energy, therefore, seems to be in the hands of PURPA-created, independent power producers, focused upon their ability to raise the substantial amounts of outside investment capital needed to finance large-scale projects.

With the glut-induced collapse of oil prices now upon us, and with the scheduled sunset of available tax credit benefits, the viability of independent power producer financing for providing the bridge to anticipated down-the-road direct utility investments is becoming increasingly doubtful, particularly for support of large machine projects where major utility interest is expected to center.

Even the feasibility of future projects based upon smaller sized machines, with their characteristically larger quantities, shorter leadtimes, and quicker returns, is threatened. Thus, it has become obvious that the most forceful move this Congress and the administration now can make to avoid a likely severe contraction in the existing wind energy base is to extend the pertinent Federal credit expiration date to well beyond 1985, while enhancing the credit itself to balance the investment incentive lost as a result of declining oil price outlook.

Specifically, Mr. Chairman, we strongly support the bill you and Congressman Lujan of New Mexico introduced in the House on March 3 to extend the Federal renewable energy tax credit through 1990, along with an increase of the credit to 25 percent.

We believe such legislation, if enacted, will assure adequate financing of projects on a scale needed to prove the levels of equipment performance and reliability demanded by ultimate utility customers.

We suspect, also, that direct utility financial involvement in wind energy, which we continue to believe is essential to its widespread usage, could be accelerated if the extended/enhanced tax benefits created by this bill could be made available at an appropriate time directly to the utility. We therefore suggest that Congress, for this purpose, consider and enact an associated modification to relevant provisions of the Internal Revenue Code.

In closing, I must note we continue to be skeptical as to the long-term benefits of the federally sponsored MOD-5 program as it currently seems to be planned. The MOD-2 technology upon which this program is largely based looks quite shaky to many of us who are outside the Federal prototyping program.

While recognizing that continued Government R&D may benefit all of us in some way, but also that it is no longer the major driver of industry development, we suggest that a more cautious, less risky, more justifiable application of taxpayers' dollars would be a project to shake out thoroughly the problems of the MOD-2 equipment, to disseminate publicly the results of such a program, and to review the understandings reached with outside interested parties before proceeding with further demonstrations.

Then, and only then, should a project be undertaken to further advance the relevant technology state-of-the-art in the very limited areas where a true potential benefit can be identified, preferably using less expensive demonstration vehicles than the planned MOD-5 units.

We hope that the comments made here this afternoon prove of some use to the deliberations of this committee.

Thank you, Mr. Chairman.

[The prepared statement of Mr. Jackson follows:]

UNITED TECHNOLOGIES HAMILTON STANDARD

Windsor Locks, Connecticut 06096
203/623-1621

FINAL DRAFT

March 15, 1983

STATEMENT FOR HOUSE SUBCOMMITTEE ON
ENERGY DEVELOPMENT AND APPLICATIONS

Mr. Chairman and Members of the Committee:

I am Art Jackson, Director of Wind Energy Systems at the Hamilton Standard Division of United Technologies Corporation. We are pleased once more to be given an opportunity to discuss our views on the status of Wind Energy and possible future Federal involvement in the field.

Much has happened in the last year of importance to the long-term development of Wind Energy as a substantial source of electricity for our nation's utilities. In general, the marketplace problems identified in my Statement submitted to this Committee last year have become, if anything, even more severe, and there also have been twists in the path of industry development that we did not fully foresee. These events have forced us to conclude that if Wind Energy is to become a major power generation option in a foreseeable time period, further action by the Federal government in assisting commercialization is now of critical importance. I will comment more specifically regarding this matter, but first, a brief report is in order regarding the status of the Wind Energy effort at Hamilton Standard.

During the summer and fall of 1982, we completed construction of the world's two most powerful wind turbines, one a 3 Megawatt machine, located in Maglarp, Sweden, and the other a 4 Megawatt unit in Medicine Bow, Wyoming (see attached photographs). In both instances we worked in close association with a large Swedish firm, Swedyards, a specialist in advanced ship construction techniques, who was responsible for wind turbine nacelle detail design and fabrication, with, in each instance, Hamilton Standard retaining overall system design responsibility. The Swedish machine was constructed under the auspices of, and with funding from, the Swedish government, while the Wyoming machine was procured by the U.S. Department of Interior's Bureau of Reclamation. Basic development work on both units was performed at contractor expense. Both machines embody the most advanced technology available anywhere in the world today (composite blades, sophisticated control electronics, active/passive load alleviation, etc.), and their ultimate cost effectiveness in derivative, serialized production configurations, in comparison to conventional fossil fuel power production technologies, still is predicted to be favorable, despite current turbulence in the oil markets.

Operations of both machines since start-up have produced extremely gratifying engineering results. Power production (see Exhibit 1) under various wind conditions has been excellent; in fact, somewhat better than forecast. With the Wyoming unit, we have also attained sustained power production at an overrating condition of 4.8 Megawatts, thus confirming the feasibility of much of the potential energy production growth (5 to 6 MW ratings with extended rotors) we expect the equipment to handle down the road. During initial runs, substantiation of the expected dynamic structural behavior of all major machine components was realized, allowing unrestricted, stable operation at all points on the power curve.

As those who read my last year's Statement will recall, it is our firm conviction that success of large scale machines will be based largely on the contractor's ability during initial design to predict accurately the lives of major components. Trial and error fixes of operational problems, an acceptable development technique with smaller units, would be too exorbitantly expensive, as experiences with the MOD-1 and MOD-2 machines have demonstrated. The foundation of accurate predictions must be the contractor's skill in closely matching measured loads and response with predicted loads and response for all major structural elements. Exhibit 2 summarizes results obtained from strain measurements on our two prototype machines. Agreement with prediction is exceptionally good, and the margins needed for the higher loads of an increased energy producing, productionized design, to be derived from the prototypes, have been clearly confirmed. Technically, we have established the capability to move in the direction of a growth machine immediately, and are well along with such an effort. Meanwhile, on both prototypes, we are proceeding to clean up all significant maintenance conditions so that standard utility hands-off operation can be sustained. One machine has received customer acceptance already, and acceptance of the other is expected momentarily.

Long ago, we recognized, Mr. Chairman, that when this stage of hardware development was reached, it would be unlikely that interest in Wind Energy on the part of the intended long-term customers, that is, the medium size and large U.S. utilities, would have matured to a level sufficient for their direct support of serialized production of units such as ours, regardless of their attractive predicted paper economics (see Exhibit 3). The problem, of course, is proof of equipment reliability. No utility that we know of is in a position to undertake, without Public Utility Commission support, the financing of equipment proof-of-reliability projects on the scale necessary to put to rest existing major uncertainties regarding unit availabilities and system operating costs. With the mixed success of existing large machine prototype projects, such PUC support is not likely to be available for some time, nor will it be soon sought. Clearly, equipment manufacturers are not in a position to generate the funds internally for the multiple projects required, nor do DOE sponsored demonstration projects of the type envisioned by the 1980 National Wind Energy Act any longer appear feasible. The future of Wind Energy, therefore, seems to be in the hands of PURPA created, Independent Power Producers, focused upon their ability to raise the substantial amounts of outside investment capital needed to finance large scale projects.

With the glut induced collapse of oil prices now upon us, likely extending for the next several years, and with the coming sunset on available tax credit benefits, the viability of Independent Power Producer financing for providing the bridge to anticipated down-the-road direct utility investments is becoming increasingly doubtful, particularly for support of large machine projects where all major utility interest is expected to center. Even the feasibility of future projects based upon smaller sized machines, which, because of their characteristic larger unit quantities and shorter lead times, provide quicker investment returns, is threatened. Thus, it has become obvious that the most forceful move this Congress and Administration now can make to avoid a likely severe contraction in the existing wind industry base is to extend the pertinent Federal credit expiration date to well beyond 1985, while ehnancing the credit itself to balance the investment incentive lost as a result of the declining oil price outlook.

Specifically, Hamilton Standard, Mr. Chairman, strongly supports the Bill you and Congressman Lujan of New Mexico introduced in the House on March 3rd to extend the federal renewable energy tax credit through 1990, along with an increase of the credit to 25%. We believe such legislation, if enacted, will assure adequate financing of projects on a scale needed to prove the levels of equipment performance and reliability demanded by ultimate utility customers. We suspect, also, that direct utility financial involvement in Wind Energy, which we continue to believe is essential to its widespread usage, could be accelerated if the extended/enhanced tax benefits created by this Bill could be made available at an appropriate time directly to the utility. We, therefore, suggest that Congress, for this purpose, consider and enact an associated modification to relevant provisions of the Internal Revenue Code.

In closing, I must note we continue to be skeptical as to the long term benefits of the federally sponsored MOD-5 program as it currently seems to be planned. The MOD-2 technology upon which this program is largely based looks quite shaky to many of us who are outside the federal prototyping program. While recognizing that continued Government R&D may benefit all of us in some way, but also that it is no longer the major driver of industry development, we suggest that a more cautious, less risky, more justifiable application of taxpayers' dollars would be a project to shake out thoroughly the problems of the MOD-2 equipment, to disseminate publicly the results of such a program, and to review the understandings reached with outside interested parties before proceeding with further demonstrations. Then, and only then, should a project be undertaken to further advance the relevant technology state-of-the-art in the very limited areas where a true potential benefit can be identified (variable speed is a possible, though expensive example), preferably using less expensive demonstration vehicles than the planned MOD-5 units.

We hope that the comments made here this afternoon prove of some use to the deliberations of this Committee.

Thank you, Mr. Chairman.

POWER PROFILE

CALCULATED VS. MEASURED

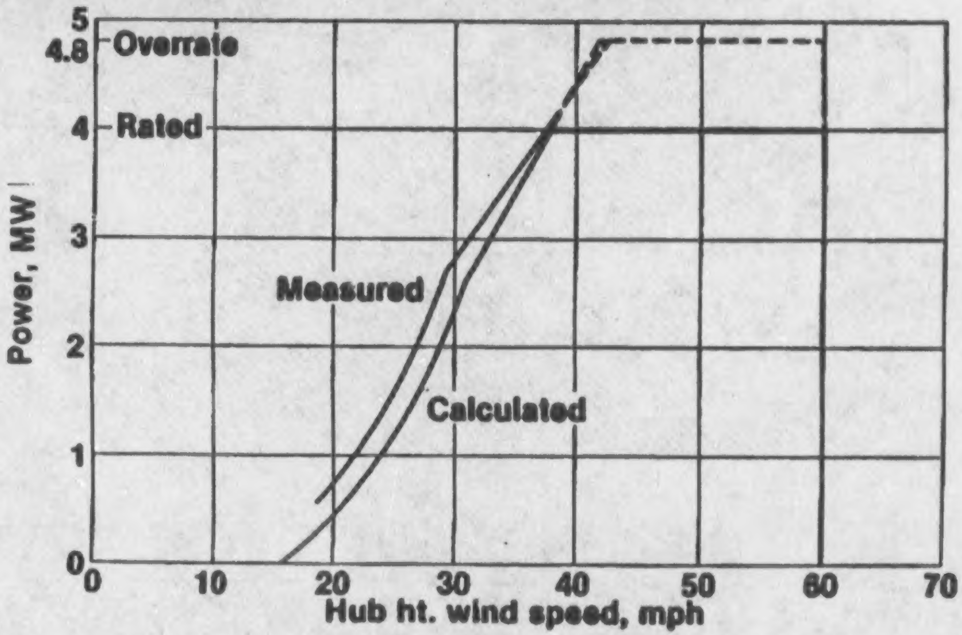


EXHIBIT 1

MAJOR COMPONENT STRESS

PREDICTED VS. MEASUREMENT

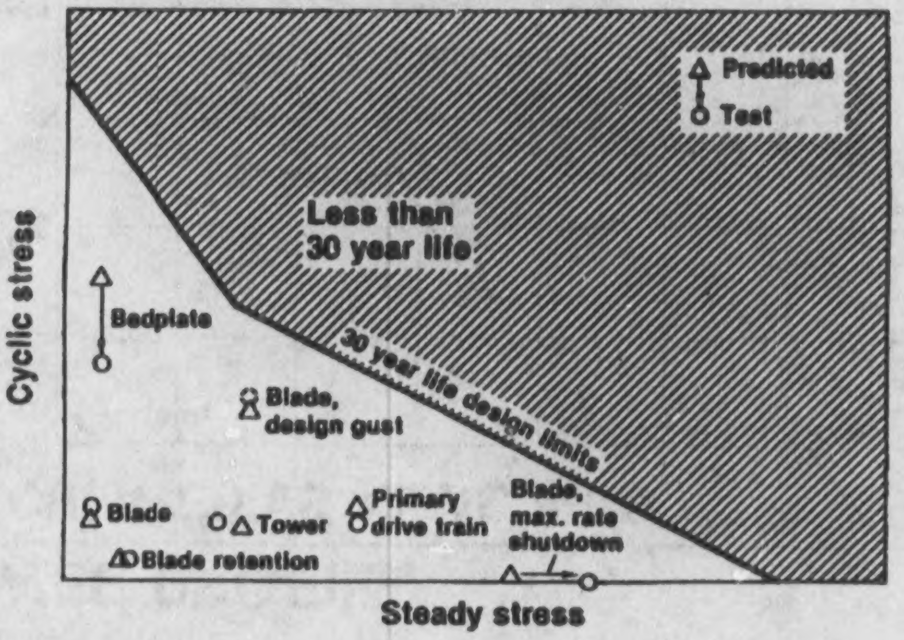


EXHIBIT 2

Cost of Wind Energy vs Conventional Sources

BASED ON HAMILTON STANDARD WTS-5 TECHNOLOGY

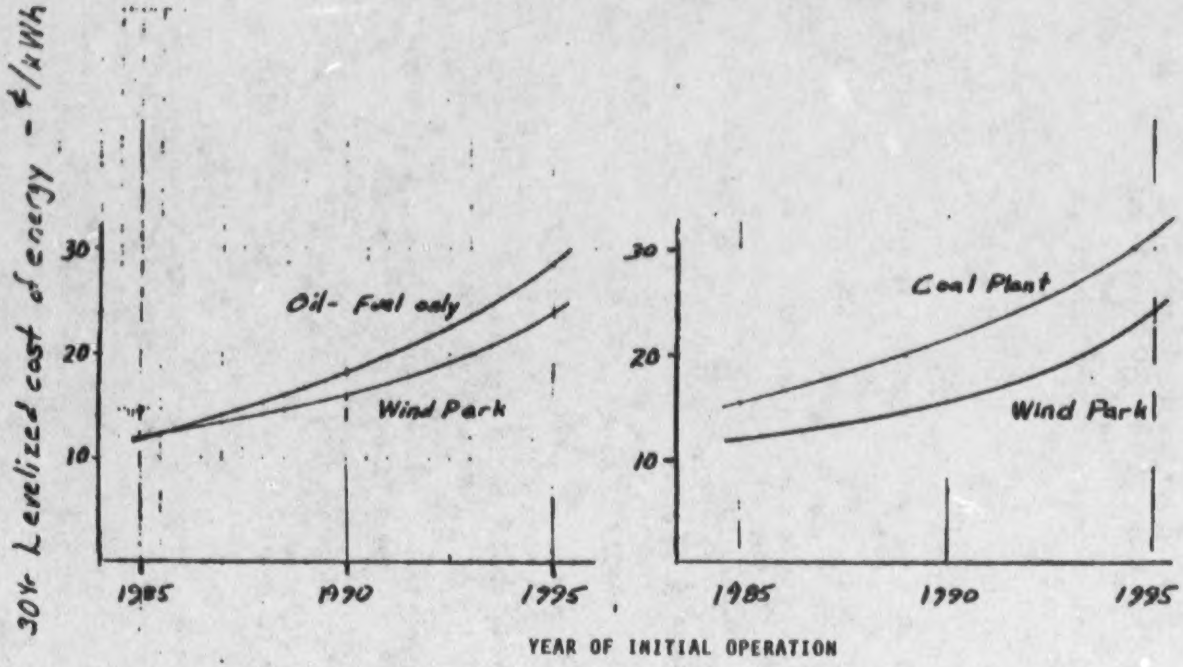


EXHIBIT 3

7% Underlying Inflation

Mr. **Fuqua**. Thank you very much, Mr. Jackson.

I thank all of the witnesses for their comments. I thought they were very, very well conceived. Particularly, I think one of the real dilemmas that we are faced with was addressed in the prepared statement of Mr. Washom.

On page 19 of your statement, you referred to the effect of oil reduced prices on the payback period for alternative energy projects, and particularly about the cancellation of a lot of synthetic fuel projects. You went on to say, and I quote: "I am sure it has not gone unnoticed that such terminations will keep America indefinitely vulnerable to OPEC and/or any other supply disruption caused by political, military, or terrorist actions abroad. The relatively short leadtimes required to implement solar thermal technologies and their long-term growth potential as an alternative to fossil fuel is our most persuasive argument for a sustained industry-government partnership in developing renewable energy technologies."

My question is, what relation is there to the tax credits, which some of you have referred to all your testimony? Is it even more imperative that we have tax credits now with what has happened in the last 24 hours at OPEC, and also with the Soviet Union lowering its price, I think, $1 to $1.50 a barrel below the OPEC price? What kind of implication does this have for the emphasis we should be placing on the extension of the tax credits?

That is not really the subject of the hearing today, but it has been referred to, and I think it is a very integral part of our considerations.

Mr. **Washom**. It is a cornerstone to our industry, our solar thermal industry, that we gain this extension and expansion.

The reason for it is this: We are, as Dr. Papay mentioned, utilizing third-party limited partnerships for the initial introduction of virtually all of these technologies. They have very rigid criteria. Their coverage of the debt service, if you will, of the interest rate payments and principals that must be paid is a demanding criterion, and so there must be the significant economic attractiveness to our technology in light of all economic conditions, both a rising oil price and a falling oil price.

As the oil price falls now to what may be a stabilized level at $29 a barrel, we obviously become less attractive to this finanical community than we were 4 months ago. The response by the Government, if we are to sustain a long-term commercialization effort in this technology, is to provide this extension of the tax credit, because the waffling of the oil prices merely delays the implementation of these credits, and now it is almost too late to start a project and have it eligible and in service by December 31, 1985. So this waffling by OPEC has caused us to delay there.

The expansion of the tax credits will return our attractiveness to the financial community, given that there is a lower oil price. TEFRA, as well, was very deleterious to our industry, as much as a reduction in the oil prices.

So we are just trying to return to the point of being economically attractive. A number of projects were on the front burner and about to spring forward until TEFRA and the diminishment of the oil prices occurred. So it is imperative that they be granted.

Mr. **Fuqua**. Do any others wish to comment on that?

Dr. **Papay**. I might just add a comment or two.

In talking to the various companies that are interested in Solar 100, one of them had done a sensitivity analysis on about the seven or eight most important variables affecting project economics. The single most important effect on project economics was the business energy tax credits, hands-down winner over any of the others.

I am afraid that it is getting much more difficult to commercialize these technologies in light of the declining price of oil. Absent continuity in terms of energy tax credits, I am afraid that the fledgling industries are liable not to reach the full commercialization state.

Mr. **Fuqua**. Mr. Jackson.

Mr. **Jackson**. I would like to just comment a bit on this, also.

We have been on the course to build a business derived from our prototype now for some years. We started out looking at real oil price growth. Here only a few years ago, it looked like 5 to 6 percent a year. That, of course, has changed with each passing year. But, even a year ago, we felt encouraged that even with a 1- to 2-percent real growth in oil price, that kind of outside investment money that we are talking about could be attractive.

However, what has happened now in the last few months has really changed that picture, finally. With the negative real growth in oil price which most people are now forecasting, it is almost impossible to put together projects with outside financing without the continued availability of tax credits in some form.

I would hasten to add that, in our view, this is still just a bridge. We are convinced that the type of equipment that we will build and others will build in competition with us, obviously, when we get out to the 1990 time period, will be very attractive, even with a much more restrained growth of oil prices than we previously looked at.

So we think that the utility market will develop, but it will not develop until we have enough of this equipment operating and operating reliably, and that is where the outside financing comes in. It is the only means that we know of to bridge this gap now that has opened up as a result of the declining and the depressed oil price scenarios we are looking at.

Mr. **Fuqua**. Mr. Jackson, I want to read a comment out of a report from the General Accounting Office that was released yesterday about the business energy investment tax credit for solar and wind energy. It says, "Almost all of the 56 companies including systems suppliers and manufacturers that GAO interviewed believe that the credit for solar and wind energy systems needs to be extended to help make those systems commercial."

I thought that was a very important statement from the General Accounting Office.

I understand our machine is fixed. Can we see those beautiful slides, of what a windmill looks like? Could we quickly rush through them; in about 30 seconds?

Mr. **Jackson**. We will just look at the first two. I will not take you through all of them.

Mr. **Fuqua**. All right.

Mr. **Jackson**. We will just look at the photographs of the two machines. [Slide.]

This is the machine in Sweden. It is on the coast south of Malmo. It is a 3-megawatt unit. It was put up last summer. It was connected to the grid in early fall. We have about 400 hours of grid-connected operation on it. It is expected to be turned over to the utility that will operate this thing at the end of this March. It has been a very successful program. [Slide.]

This is its compatriot in Medicine Bow, Wyo. The hardware was funded by the Department of the Interior. This is a 4-megawatt machine. It has been run to sustain 4.8. It has actually absorbed power close to 6 megawatts.

It went on line a little bit behind the one in Sweden. It has about 200 hours of on-line operation. It is also very successful in all respects.

Between the two machines, we have accumulated over 1,000 megawatt hours, a considerable accomplishment at this stage of their development.

Thank you. That is all.

Mr. **Fuqua**. Dr. Papay, what is the status of the Solar 100 project that you referred to in your testimony? Do you expect to proceed with that shortly, or is that still in the planning stage? When I say planning, I mean evaluation.

Dr. **Papay**. At present, as I mentioned in my testimony, we had four responses to the solar program opportunity announcement. Two of the respondees did not have the same sense of urgency as far as moving ahead, and I think that is in part due to the efforts in the Federal repowering program. I think they were looking at how it would all fit together. They want to continue to be considered in the future.

The other two gave us quite detailed proposals for 100-megawatt plants. We entered into one-on-one with both of the companies to try to understand what would make the program economics go. We are about to complete those evaluations. Both of the companies are extremely interested. I am not quite sure whether we will be able to get zero, one, or two 100-megawatt plants out of that.

Because of the falling price of oil and the uncertainties on energy tax credits and what have you, I think that one of the potential suppliers is about to go into a deferral mode. In the case of the second company, we are going to try to work the deal, and I would say it is about 50–50.

But that evaluation should be completed in the next few weeks.

Mr. **Fuqua**. How far do you think the Government should go in these types of programs, particularly in the demonstration phase? Should we be involved beyond component testing, or should we even be involved in component testing? Should we be involved in conceptual design? How far do we go?

We get hit from both sides on this—from those who think that industry should just take off and run with it and develop it commercially—and we have budget constraints. Where is the proper Federal role in developing these types of technologies, if there is one?

Dr. **Papay**. I don't know if I can give you a single answer, because there is sort of a continuum, and the answer may vary depending upon the individual technology.

I think what is required conceptually is to have a clear and continuous path going from research to development through demonstration and commercialization. I frequently refer to the fact that if you look at a developmental progress chart, there tends to be a little triangle in the lower right which says, "commercialization," and everyone assumes the problems are over.

I think, in individual programs, there may very well be, and in most cases there will be, some role for the Federal Government right through demonstration. Perhaps the central receiver technology is a good example of a possible way the public and private sectors can come together to try to commercialize the technology.

With the central receiver program, the front-end research was done by the Federal Government with industrial subcontractors. When it came time for the demonstration phase—that is, Solar One, the 10-megawatt plant that I referred to earlier—then a joint effort with funding both from the Federal and the private sector to bring that plant into reality was necessary. Taking it from the demonstration phase to commercialization, the need for support of one shape or form from the Federal sector generally is required.

In the case here, what we are talking about are the energy tax credits, some way to get over that initial commercialization hump. I think the Federal Government has a role, if you like, which continues all the way through, but the level or type of assistance can change as the technology goes from research to commercialization.

Mr. **Fuqua**. Mr. Tharpe, on the MOD-5, do you think it can be competitive with conventional coal or nuclear power?

Mr. **Tharpe**. Mr. Chairman, I think one thing that we have a very high degree of confidence in is the forecasted economics of the MOD-5 machine.

The hardware costs of the machines are staying exactly where they were when we forecasted them 3 years ago. We have gone through a very extensive check of our cost projections using the learning curves at our gas turbine business, which was quite successful in our experience. We also took the learning curves of our nuclear power business and compared those to those that we are forecasting for the wind turbine.

That was then supplemented by an item-by-item buildup, looking at 1, 2, and 3 units and then 100th unit.

On a fourth check, we then compared the machine to what we call equivalent classes of machinery. A very good set of curves exist for looking at things such as large tractors, drag lines, automobiles, ships, gas turbines, and so forth, in which you can compare as mature equipment and get a good indication of ultimate mature product costs by doing a simple-dollar per pound comparison.

So we have right now what we think is a four-way cross-check on the MOD-5, and we are quite convinced that the machines and the numbers we are projecting will get below 5 cents a kilowatt-hour; that is, assuming the wind regimes that are projected for it, which are the moderate and high wind regimes.

Mr. **Fuqua**. Last year, you testified that you needed $3 million in fiscal year 1984. In examining the budget, I think you are requesting $6 million. Can you account for that increase?

Mr. **Tharpe**. I think I can.

Several things have happened in the program in the last year. One is that we have expanded the industry part from about $20 million to almost $60 million, so the Government share of the program is substantially less than 50 percent.

We have also, with NASA and DOE concurrence, been working very hard to assure that the machines will come on line in a reliable and, particularly, safe fashion. We have made some changes to the machine in the past year that I think both enhance its reliability and improve its economics. We have changed from constant speed to variable speed, which makes the machine much more benign as it operates with the utility grid. We have increased the rating of the machine by about a megawatt.

We are also going through the machine now and eliminating, to the greatest possible extent, what is called reverse bending. If you look at the failures that wind turbines have experienced, many failures have resulted from this type of cyclic loading. In the last 4 months we have worked our way through the MOD-5 turbine and to assess all areas in which such loads exist. We have also made some improvements in the gearboxes.

Beyond that, we have added a substantial portion of testing to the program, particularly in the area of the wood blades, Those, in the net, add substantial costs to the industry side and add about $4 million, in our present estimate to the Government side. We think the Government run-out cost is going to be, instead of about $26 million, about $30 million.

One thing I would express, Mr. Chairman, from General Electric's viewpoint is that it is our objective to make the machine successful, and that comes first. Schedule comes second, and cost comes third. That is the way we have to conduct ourselves in the environment in which we are now going to sell a machine to a commercial customer.

We are willing to take the cost impacts of our changes on our side of the equation, which is on the hardware. We hope the Government will do the same on their side.

The $6 million, then, in 1984 works out in the following fashion. We had asked for $10 million in fiscal year 1983. As near as we can tell from DOE, we will probably receive about $8 million. We do not have the $8 million as yet. The check is not in the mail. [Laughter.]

But we are hopeful of getting at least the $8 million, so that there is a $2 million movement from 1983 into 1984. If you will notice, in the previous testimony we had said $2 million to $3 million in 1984. So $2 million carry on is added to that. Then, we think we have changed the program by about $4 million in total runout.

I want to say that none of that represents cost overrun. In addition to scope, these changes are necessary to assure ourselves that we are doing the right things on the machine. Thus, $6 million is possibly the correct number for fiscal year 1984.

I would also add that, we are in the very final stages of contract negotiation on one machine. Those contracts are going through our corporate headquarters—in fact, I will be there next week—and they are going through the board of directors for one utility. So I would anticipate we will have one machine sold within about 6 weeks.

We have a very good commitment from EPRI, the Electrical Power Research Institute, to continue with us in those machines for the 5-year period and to share the cost of improving and enhancing the performance of the machine.

So, from the industry side, I think we have our act pretty well put together, and we hope that the Government will be able to sustain its role.

Mr. FUQUA. Larry, I understand you have to depart, and if we have any questions for you, we will submit them to you in writing, and you can respond to them.

Dr. PAPAY. I would be most happy to, Mr. Chairman.

Thank you.

Mr. FUQUA. Thank you.

Mrs. Schneider.

Mrs. SCHNEIDER. Thank you, Mr. Chairman.

Let me apologize for my coming in and out, and missing much of the testimony of the very honorable witnesses, but I am afraid I am fighting several crises at the same time.

I would like to ask some general questions, and I would prefer some specific answers, if possible, relating to the Energy Research Advisory Board report on solar energy.

Have any of you read the report, and are you familiar with it?

Mr. WASHOM. I have to admit I have not only read it, but I also was a member of the Board, so I helped draft it.

Mrs. SCHNEIDER. Terrific. Well, then I will not ask you your opinion of the report. I don't want any conflict of interest here.

The other two gentlemen have not read it?

Mr. THARPE. I have not, Mrs. Schneider.

Mrs. SCHNEIDER. All right.

Mr. JACKSON. I read it some time ago, but I am not fresh on the subject at all.

Mrs. SCHNEIDER. All right. Well, I might assume, Mr. Washom, that you are, then, an advocate of the report, and that is precisely what I was looking for.

I am a strong believer that if the Board goes through the efforts of thoroughly analyzing what is going on at DOE and makes recommendations and substantiates their findings, those recommendations ought to at least be considered at a bare minimum, perhaps some even followed.

Are there any particular recommendations that you made, that you would like to highlight for this committee?

Mr. WASHOM. By way of background, the report was a very difficult process. The Chairperson, Victoria Tscninkel, did an excellent job of putting it together. I believe we heard 116 different presentations over a 5-meeting period of 3 months and came up with a final report. It is a credit to her that the report got out.

In terms of the recommendations, I think foremost is the fact that there is a potential of losing the Federal investment to date in the solar energy R&D. If an abrupt, unorchestrated, transition from the present development of technology to almost exclusively long-term, high-risk R&D occurs, then a substantial amount of Federal investment would be lost. We would have an unraveling and disassembly of the technical teams that have been formed. As a whole, you would probably set back the possibility of this technology reaching the marketplace definitely into the mid to late 1990's.

So the foremost recommendation that I would highlight now is the prudence that the ERAB report emphasized on preserving Federal investment and preserving the momentum that this country has gained in becoming world leader in the technology development.

Subwork that was done was also emphasized, the need for the basic R&D sciences in building an adequate university program. Unfortunately, the universities have the least powerful lobbying group in these technologies and have suffered in the past. So there needs to be a balance between the basic research program and the more applied.

Finally, I think the Board said that system test and evaluation, which previously was called demonstration projects, is not bad. It is not generically bad. As Dr. Papay mentioned, in some cases, it is in fact valuable to take this technology to a reasonable scale of system test and evaluation, so not only the Government but also the financial community and investors in utilities and ratepayers and taxpayers will all have a grasp of the reality of the different technologies.

Mrs. SCHNEIDER. This committee, for some time now, has been concerned with some of the management at DOE as they proceed to make decisions relating to conservation and renewables.

I was wondering if you might be able to make some additional comments—let us call them constructive criticisms or recommendations—of how they can better improve upon the quality of their R&D projects. How would you like to see DOE change to better fulfill——

Mr. THARPE. That is a question that anybody would have to be very brave to walk into.

Mrs. SCHNEIDER. We know that you are all very brave, so we will give you that chance.

Mr. THARPE. I live a fair portion of my world in that way.

In my own experience, Mrs. Schneider, I think that, in general, DOE contains a very highly dedicated group of people who have struggled through, and dealt with, what I would call more than difficult circumstances. It may not be what we want, but it may be very good under the circumstances in which they have to operate.

So I think there is a kudo there that I would personally give to most of the DOE people just for their degree of dedication.

Mrs. SCHNEIDER. Well, I would agree with you insofar as the dedication and the job performance is concerned, but maybe there is something that we can do from this congressional end of things to make the conditions under which they work a little bit better. If you see that, that is what we are grasping for.

Mr. THARPE. Yes, that is what I wanted to address.

I have spent my entire career in the energy business since I graduated from college, which is getting to to be a pretty long time now. One of the things that you are taught in General Electric when you go to work, is that you should remember, when you design that turbine, that when you retire, it will still be running.

There is a longevity, I think, to doing things in the energy arena that is very difficult to fit into the Federal process. It transcends careers for most of us.

I think that is the biggest difficulty I see with DOE. It is the changing of people; sometimes being impatient for results; wanting to plan development and research in a way that is not responsive to the market and to the rate at which technological progress can be made. It is in demanding performance versus schedule that I think most of us in the commercial side realized a long time ago we cannot meet. I have seen a number of times in DOE when we moved rapidly to hardware; concluded no, that will not work and then had to move back again to R&D. I think it is a mistake to skip steps.

Mrs. **Schneider**. All right. Thank you. Does anyone else care to comment?

[No response.]

Mr. **Schneider**. I should perhaps move from my very general questions to something else.

In some of the economic forecasts that we have been seeing lately that are attempting to predict what the cost of energy will be, energy derived from alternative and renewable fuels, what do you see as the earliest date that these fuels will be competitive with some of our fossil fuels? Have any of you done any forecasting, and can you give us an idea as to when renewables could be cost competitive?

Mr. **Tharpe**. Are you thinking of renewables as wind, solar heating, and so forth, in that context, Mrs. Schneider?

Mrs. **Schneider**. Yes.

Mr. **Tharpe**. I think that, pretty clearly, they tend to be competitive when you have an energy price that is the equivalent of about $60 a barrel in oil. There is a quite good consistency; if you evaluate a number of the solar technologies, they would be competitive at about that point.

Our evaluations indicate, incidentally, that the economy would in fact be able to handle something on the order of $60 a barrel for oil, but when you get much above that, it severely impacts the economy.

It is interesting, in the tax credits, that if you take a competitive situation at which oil is at $34 or $40 a barrel, the tax credits make the renewables appear to compete against about $60 oil.

Mrs. **Schneider**. Well, since you bring up tax credits, let me just say that when the tax credits were rumored to be repealed about a year and a half or so ago, I met with representatives from the administration, and in putting forward our arguments of how valuable those tax credits were, the response that I was met with was, Well, nobody even uses those tax credits, so how can they be so valuable? You don't have any numbers to substantiate it.

I notice that—in the GAO report just recently—that the chairman was referring to, over the lifetime of the tax credit, the Treasury had estimated that $130 million would be claimed by businesses. This is really down from the 1981 estimate that was made of $501 million assumed to be claimed by business.

I would like someone to address that strange trend.

Mr. WASHOM. I would like to just offer my comment because, on that particular point, the reason that there is a downturn in the use of that energy tax credit is that even the mere threat that the energy tax credit is going to be repealed creates a de facto repeal of it from the financial community, because you take eligibility of those tax credits when you put them in place, and the threats that were going through at that time—if you had started on a project and brought it into service today, you stood a good chance of not having that tax credit available to you. The tax credits are the tilting factor. So the mere threat is a de facto repeal in our own industry.

Mrs. SCHNEIDER. But, quite frankly, that threat was based on numbers that were used to analyze before this administration came in.

Mr. WASHOM. I think that might have been used on the 20-quad or 20-percent energy goal by the year 2000 as well.

Mrs. SCHNEIDER. I see.

Mr. WASHOM. I just briefly read the GAO report yesterday. They also made mention that some DOE officials were quoted in that report as suggesting that there would be a net gain to the Treasury rather than net loss over the benefit of jobs and income and property taxation.

Mrs. SCHNEIDER. Yes.

Yes, Mr. Jackson?

Mr. JACKSON. I would like to add to that, too.

I think, similarly, the perception of oil price has had a similar depressing effect, because, 2 years ago, we were very much involved in a large 80-megawatt project that was going to be put in Hawaii. Of course, there were the credits there, but the perception of oil price real growth of 4 to 5 percent a year was a generally accepted fact in the banking community, for example.

That all changed by last year, and it lowered very substantially. That certainly has been as big a dampener on putting these projects together. No large projects have been launched, actually none, and I think that is a very large degree, without knowing the details of it, as to why the tax credits have not been used.

I would like to go back to your earlier question and say where this thing really is going to be competitive, and I mean competitive without the tax credits. We believe that by 1990, with the current trends in energy prices that most people are currently forecasting—now, that is different than it was a year ago—if those forecasts shrink further, if oil collapses to $20 a barrel, and that stays down there for a while, it is going to be that much longer. But if it stays at $29 a barrel and starts to go up with inflation, just a modest 4 to 5 percent underlying inflation, we are convinced that these renewables in wind, anyway, will be directly competitive with oil, coal, natural gas by 1990.

But what do you do in the meantime? There will be nothing out there to build in 1990 if we don't have a number of large projects in place. It does not do any good to put one here and one there. We have to have quantities of these things.

Mrs. **Schneider**. So how do we increase the quantity of these projects?

Mr. **Jackson**. In my opinion and the opinion of my company, the 15-percent extension will assure a healthy continuation of project development. If that is enhanced to the 25 percent, I think we look forward to, without any direct Government assistance, many projects going on line with outside financing between now and 1990 to get enough equipment in place so that the machinery will be proven and can be in a position to be bought heavily by utilities in about 5 or 6 years.

Mrs. **Schneider**. Very fine.

Mr. **Washom**. I would just like to repeat, our industry's association position is that what is needed is the extension of the energy tax credit to December 31, 1990, and an expansion of the tax credit from 15 to 25 percent in order to gain back the loss that we received with the passage of TEFRA and the dwindling oil prices.

Mrs. **Schneider**. Do you think that business is adequately aware that these tax credits exist? Do you think that we could do a better sales pitch? For example, when GE does their advertising for one solar installment or another, you can mention at the same time that you can experience a significant tax credit.

Mr. **Tharpe**. I don't want to speak for corporate advertising, but their messages are much more simple than the intricacies of the tax laws. It is "We bring good things to life," and they just keep hammering on that.

Mrs. **Schneider**. I keep singing that at night all the time. I wake up thinking, "We bring good things to life."

Mr. **Tharpe**. You have to admit it is a catchy tune.

Mrs. **Schneider**. It works.

Mr. **Tharpe**. It is a very responsive ad, and in a word it is, "Keep it simple." So I would not think one would try to tackle an issue as complex as energy tax credit in advertising.

In general, I would say this, though, that with the customers that we deal with who are affected by high energy prices, they are quite knowledgeable of those credits and take advantage of them in every fashion that they can. The difficulty that we bump into is the uncertainty issue.

As you may have heard just recently, the IRS proposed that the third party treatment on capital cost be treated as though it were a utility.

Mrs. **Schneider**. Oh, yes.

Mr. **Tharpe**. When that happens, everything goes up in the air for awhile. So I would think that Byron is correct; it is largely an influence of uncertainty.

Mrs. **Schneider**. All right.

In closing, I just want to ask of you, Mr. Tharpe, that when our good chairman here and other members of the committee go to bat to see that we have this extension of business energy tax credits, I would hope that we are not going to find the likes of General Electric or perhaps the coal industry and nuclear industries and some of the other "big boys" fighting us on the other side. Do you have any feel on that?

Mr. **Tharpe**. That really does put me on the spot. [Laughter.]

But I will have to respond.

The company in general does not take positions on issues such as specific tax credits. It tries very hard to take a statesmanlike approach and deal only with issues that are on a national scale.

For example, General Electric is a very strong supporter of the International Monetary Fund. It affects the whole Nation, but it also affects General Electric. But it is very careful to try to avoid taking positions on narrow issues, because we are such a diverse company in general, we would find that on such narrow issues, a position that is beneficial to one portion of the company is almost surely detrimental to the other.

You will find general managers like myself, when you get us into this type of uncomfortable position, become cautious about espousing one position versus another. We will try to stick plainly to the facts and leave such decisions as tax credits in the hands of the administration and Congress, which I think is really where they belong.

Mrs. **SCHNEIDER**. Good. We will keep that in mind.

Thank you, Mr. Chairman.

Thank you for your testimony.

Mr. **FUQUA**. Thank you, Mrs. Schneider.

Mr. Bateman.

Mr. **BATEMAN**. I have no questions, Mr. Chairman.

Mr. **FUQUA**. Thank you.

Mr. Simon.

Mr. **SIMON**. Just one question. I am a new member of this committee, so my question may be a little unsophisticated. But I am interested in this solar area.

We built a new home about a year and a half ago, and after examining things—and I am not the mechanical type—I decided I didn't want a bunch of pipes and everything, so we built passive solar, and we are very pleased with it.

But a few years ago, the President of Cyprus, Archbishop Makarios, died, and I was part of the delegation President Carter appointed to go over there. We went through ceremonies for about 3 days, and while I was over there, I said that I would like to visit this refugee housing that we helped to build with U.S. funds.

And so we went to visit the refugee housing, and here we saw these refugee homes, 55 percent built with American funds. Every one of them has a solar water heating unit on it.

Now, somehow, we can help get solar water heating units in Nicosia, Cyprus, but we cannot get them in Carbondale, Ill., or Florida or Rhode Island or California and elsewhere.

Now, would it be of help to furthering the process and the refinement of the technology if we were to declare that, starting in 1985, public housing units in the United States, that are one-story would all have a solar heating device for hot water? Are there practical steps like that that we can take that would advance the technology and be meaningful, or is that a waste of money?

Anyway, that is my one uncomplicated, unsophisticated question.

Mr. **WASHOM**. I think there are good opportunities for the Federal Government in public housing projects, military projects, and the like, to require that a life cycle cost of alternative energy—let's say, in your case, on a heating and cooling basis—to merely evaluate that, and if it comes down on the side of renewable energy, then that is the preference, although the capital cost would initially be higher for that system, but the life cycle would be favorable toward renewable.

There have been programs similar to that. I believe, if I am not mistaken, in the SENSE Act, which has just been introduced on the Senate and the House side, there is such a move in the military applications market of that type of philosophy being applied.

So the Federal Government, without spending their own funds directly, could in fact ask that this life cycle cost be evaluated for these public works projects.

Mr. **Simon**. I guess my question goes a little beyond that, if I may interrupt, and that is, assuming that you study it and there is a net cost over a 10-year period of $150 per housing unit; if we make that kind of investment, does that advance the technology?

Mr. **Washom**. That not only advances the technology by having more people in the marketplace—you have more companies wanting a piece of that business, so that would in fact induce a number of innovative companies to enter the market. But, second, it would advance the commercialization of the technology by providing a greater volume of business. Right now, we are production sensitive. We need volume in order to bring the cost down, more so than we need technology, in the particular application you referenced.

Mr. **Tharpe**. Could I add something, Mr. Simon?

Mr. **Simon**. Yes.

Mr. **Tharpe**. I guess I will have to disagree with Byron on this one.

I always get concerned about programs that do not flow through what I will call the normal business structure, because a major part of establishing any business is to have the business come into being, not just the hardware, not just the hardware volume, and not just the product, but you must be building a continuing relationship between manufacturer, sales distributor, and purchaser.

The unfortunate part of the problem in the approach that you are suggesting, wherein you have a targeted section of housing, is that it is quite difficult for industry to respond to such programs which issue from many Federal agencies around the country. It is an artificial stimulus; whereas, I think, to make a business move forward soundly, one has to be making decisions on what are the right regions of the country I want to put this product in; is this the right sales and distribution technique; am I selling to the right customer; am I advertising properly, and so forth.

That is what I think, over the long haul, will give you a good business. A "spike" which comes by virtue of a focused Government activity frequently is, I find, disruptive to the market, because it provides a "spike" in sales which you respond to. These sales then go away because they can not continue, because they are not a part of the ongoing market process.

It goes back to my comment to Mrs. Schneider. This whole process of commercializing, a techology and making a product is a long, long affair. Little blips and hits don't really do that much for the business.

Mr. **Simon**. Mr. Jackson, do you care to add anything?

Mr. **Jackson**. No, I think I am on Bobby Tharpe's side on that one.

Mr. SIMON. All right.

Thank you, Mr. Chairman.

Mr. FUQUA. Thank you, Mr. Simon.

Mr. Gregg.

Mr. GREGG. Thank you, Mr. Chairman. I have no questions.

Mr. FUQUA. Thank you, gentlemen, very much for being here today. We appreciate your contributions to our testimony. Good luck to you on your projects that you are working on.

Mr. THARPE. Thank you very much.

Mr. WASHOM. Thank you.

Mr. FUQUA. Our next panel will be Dr. Leslie Levine from Jaycor, Dr. Patrick Takahashi from the University of Hawaii and Dr. Charles Berge of Grace Geothermal Corp.

Dr. Levine, we will begin with you. If you have a prepared statement and wish to make it part of the record and summarize your statement, we will be pleased to have you do that.

STATEMENT OF DR. LESLIE S. LEVINE, VICE PRESIDENT, BIOMASS ENERGY RESEARCH ASSOCIATION; AND DIRECTOR OF ADVANCED TECHNOLOGY, JAYCOR

Dr. LEVINE. Thank you, Mr. Chairman. I would like to do that.

Mr. Chairman and members of the committee, my name is Leslie Levine and I am here as the vice president of the Biomass Energy Research Association [BERA]. BERA is a nonprofit education and scientific organization established to promote public understanding of biomass energy and of the role of research and development in biomass energy.

We have as members, representatives from universities, utilities, and the business community.

I would like, if I might, to begin my remarks with some general comments on the Federal role in R&D in the area of renewable energy, then turn more specifically to biomass energy and, finally, to a set of recommendations on what BERA believes constitutes a base-level federally sponsored R&D program in biomass.

The general issue of the Federal role in R&D, and particularly in renewable energy, is one that has bothered me for quite a while. I was one of the veterans of the Department of Energy that Congresswoman Schneider spoke of before. Both within the Department and, since 1981, on the outside, I have been concerned about these general questions.

I have read with considerable care the statements of the administration on appropriate Federal roles. I must say, by and large, I would agree with them. It seems to me that the administration, at one time or another, has identified several different criteria which justify a Federal role.

For one, they have included activities which are so general that no particular company can adequately benefit directly. This would, for example, be the case with basic research or generic research. It also would be the case with research on environmental issues associated with certain technologies. This criteria would also include other traditional areas of Federal activity. For example, NASA has had, for a long time, technology transfer programs to tell private industry about technical advances supported with Federal R&D funds.

A second criteria the administration has employed, applies to areas in which the private sector is made up of so many small companies or users that no one organization can justify or afford the kind of R&D investments that are needed. This would be the case, for example, with agriculture or with the biomedical sciences.

A third would be that the technical risk or cost of a given project is so large that it is hard for even a large company to justify it. This is clearly the argument behind the continued Federal investment in nuclear fission projects, such as the Clinch River Breeder Reactor project.

Finally, there is the criterion that it is ultimately the public that will benefit from the successful completion of the R&D. This would be the case, obviously, where the public is the purchaser, as for example, military R&D. Clearly, it also applies in some sense, in areas such as agriculture and energy and other fundamental bases of national well-being.

It seems to me that each of those criteria are applied by the administration in one program or another, and each has strong historical precedent. It seems to me, however, that in the areas of renewable energy and conservation R&D, these have not been applied well.

The potential national benefits from the successful completion of these programs are extremely large, as the earlier speakers have indicated and as studies by all sorts of groups over the last decade, including Congress' own OTA, have substantiated.

Furthermore, the R&D investments needed are small when compared to other programs. Finally, for most of these technologies, there have not been industry groups. The industry groups have in fact developed around the Federal programs.

In the renewable energy industries at large today, one sees many companies struggling to improve products, find market niches, and make sales. I believe that what these companies need, more than anything else, is a supportive DOE program that concentrates on doing the long-term R&D, as well as on providing support for the generic activities like testing resource evaluation, and for technology transfer activities.

I believe that DOE has to assume a positive leadership role in helping the private sector and in forging the kinds of public-private cooperation that some of the speakers have referred to before.

Let me turn, if I might, more specifically to the case of biomass energy, since, in many ways, it represents an excellent case study for some of these points.

I should point out that of all of the renewable energy technologies that we have heard about today, biomass is far and away the most widely used. In 1983, it is estimated that over 3 percent of the Nation's delivered energy came from biomass. This is, strikingly, an amount comparable to that actually delivered from nuclear power.

Most of this biomass energy was in the form of direct burning of wood and wood wastes, much of it by the forest products industry, much by individuals in their own homes. There have been smaller contributions from other forms of biomass energy, such as from wood gasification, from methane production by anaerobic digestion, and, of course, from ethanol from corn.

What is striking, given the size and significance of biomass energy, is how it has been relatively ignored by the public and policymakers alike. It was only within the last year, in fact, that DOE's Energy Information Administration even began to tabulate data on the use of biomass as part of its national energy statistics.

The reason for this relative ignorance of biomass stems, I believe, from its highly decentralized nature. The ultimate strength of biomass energy is the close proximity between resource and user, but this also means that the industry tends to be extremely small, scattered, and diversified; in fact, just the kind of industry which I believe meets some of the criteria that I discussed as meeting traditional criteria before for the need for a Federal R&D support role.

We hope, through organizations like BERA, we can at least make the public aware of what is going on, of the potential of biomass.

At the same time that the current importance of biomass is ignored, its very commercial success and favorable economics compared to other renewables leads some people to argue against the need for a vigorous Federal R&D program. They would argue that, with 3 percent of the Nation's energy, there is no need for further R&D in biomass, or that there are perhaps more deserving technologies.

I believe that this assessment is incorrect. There have been a number of studies, again referring to the OTA studies in particular, that clearly show there are several advanced technical areas in biomass energy where relatively modest R&D investments will yield significant benefits, and these are benefits which will complement the use of biomass that is occurring naturally today and not displace it.

As an example, there have been studies that have indicated that new kinds of herbaceous crops, that energy "grasses," for example, that could grow perennially on a farmer's untilled pastureland, and be an enormously important source of energy to him. You could get very high yields with such crops, without competing with prime agricultural land. And yet DOE is proposing that we spend absolutely nothing in R&D in this field. I believe that that is a mistake.

Another example with which I am familiar is the area of aquatic plants, which also have the potential of very, very high yields and, importantly for the long term, not competing with agricultural lands or forestry lands. These, too, are recommended for a significantly lower budget in fiscal year 1984.

A final example of the need for biomass R&D activity stems from the observation that we are now in the throes of a revolution in biological techniques—what is collectively referred to as genetic engineering.

I have personally been involved over the last year in a study of the potential of this genetic engineering technology for biomass energy. It is clear that the potential is very great, indeed, both for improving the efficiency of conversion processes and, even more importantly, for improving the productivities or characteristics of the plants being grown.

It is also clear from that study that, although there is significant private investment in genetic engineering, essentially none of it is going toward biomass energy. This is not because the payoff is not there, but because there are higher payoffs in the near term, and payoffs which are easier to capture in terms of patent position.

The genetic engineering firms we spoke to in this study all indicated that they believed biomass energy was an important and interesting area of research, but one where they would wait for a Federal R&D program to support their work.

Overall, the estimates that have been made indicate that biomass energy could contribute as much as 10 or 15 percent of the Nation's energy supply by the turn of the century. I would estimate that perhaps 50 percent of this contribution depends on R&D advances to improve efficiencies or economies or to develop whole new processes. These benefits are large indeed.

A major reason for these large benefits we expect from biomass, and indeed are seeing from biomass, I should point out, is that, uniquely among the renewable technologies, biomass has the potential of producing the solid and liquid and gaseous fuels that so much of our energy economy depends upon.

Unlike many of the other renewables which primarily produce electricity, biomass thus can be suited to a whole range of applications such as transportation fuels.

A second long-term benefit which we have only begun to look seriously at is the potential of biomass energy to provide increased security to the Nation. The inherently small scale and dispersed nature of the resources and the fuels that they produce make biomass an ideal backup for energy disruptions. I might point out that the Swedes have had a vigorous program in this area for a number of years.

A third benefit that has also not attracted enough attention, in my opinion, is the potential of biomass energy to create jobs. Biomass can produce fuels at competitive prices in ways that create jobs in the regions where the fuels are being produced. This has an enormous potential, particularly in the rural areas where unemployment and underemployment have long been a real problem.

I believe that for these benefits to occur will not require significant large Federal outlays, but it will require a sustained and vigorous Federal biomass energy research program and an effort to disseminate the information that now exists about biomass technologies and their potential.

Given all of this, the proposed administration budget is a real disappointment. I believe that biomass has traditionally been underfunded among the renewable technologies. What we are seeing here is a 40-percent decrease from last year's already low level. Some of that has been camouflaged by combining the Biomass Energy Program budget with budget requests for the Office of Alcohol Fuels and the energy from municipal waste program.

I believe there are good technical and programmatic reasons for combining those programs, but when evaluating the budget and the changes in the budget, it is important to distinguish between the ongoing work in the three different areas.

The proposed funding that relates to ongoing biomass energy efforts is $8 million. This should be compared to the $20.5 million which Congress authorized last year for the biomass energy efforts. The low level is insufficient to continue the valuable R&D programs under way. I believe it is also entirely out of keeping with the nature and potential benefits of biomass energy technology.

Let me make a few brief, general comments about the budget and then provide you with the numbers that are in the back of my written testimony.

First of all, the proposed budget is unbalanced in favor of conversion technology R&D. Essentially, all of the feedstock production R&D—that is, the R&D on how to make fast-growing trees or new kinds of plants that themselves produce oils—virtually all of that has been eliminated. There is only $1 million left, whereas the biomass program had run, for a number of years, with 50 percent of its R&D budget going to production.

I believe that this is particularly foolish. The ERAB study that we spoke of before made the point that the R&D benefits were going to come primarily by from the production side. This is the observation of my studies as well.

This R&D will not be done in the private sector. Traditionally, feedstock R&D—corn, trees, and such—has not been done primarily by private companies because of the difficulty in capturing a proprietary position. That is why USDA has for so many years had active plant-breeding programs. Although in this case, I do not believe it will be done by USDA, because of their focus on food and fiber issues.

A second comment is that the regional biomass program which Congress explicitly called for in the fiscal year 1983 budget action has been eliminated. BERA believes that this activity, modeled after the extremely successful work conducted by Bonneville Power and TVA in recent years, is very important and should be continued.

The great strength of biomass is its regional nature. There are appropriate biomass resources, technologies, and end-use requirements in virtually every region of the Nation. I believe it is an entirely appropriate role for the Federal Government to catalyze these regional activities by providing small amounts of seed money for regional planning, resource and technology assessment, and for making a start in developing regional-based biomass activities.

Let me now talk very briefly about some of the specific elements within the budget. I might point out that I am not going to address those elements that pertain to the work of the Alcohol Fuels Office or the municipal waste program.

I believe, or BERA believes, that the biomass feedstock R&D program should be funded at $7.5 million. This would be roughly the same as this year. It would provide $3 million to wrap up the longstanding work on short rotation woody biomass. These are plots that have been grown for 6 and 7 years. If we cut off research now, we will lose much of the benefit of this investment, because we will not understand the proper cultivation techniques or yield potentials.

I believe that the herbaceous species program should be funded at $2 million. This would start a significant effort at looking at both herbaceous plants like grasses that would grow on low-value agricultural land and also plants that are particularly suitable for arid regions of the country.

The aquatic species program, which has been producing extremely interesting results regarding high-yield aquatic biomass that could produce, with minimal conversion, oils and chemicals of great potential value, should be continued at $2.5 million.

BERA recommends that in the conversion area, the budget also be $7.5 million; and that it be evenly divided between basic studies in thermochemical conversion and biochemical conversion. As I said before, we are at the beginning of a revolution in biological techniques, and many of these are just waiting to be applied to the problems of biomass energy conversion.

We believe that environmental studies and planning need to be continued at a minimal level. The DOE biomass program has been criticized in a number of places, including the ERAB report, for a lack of good, solid, long-range planning. I believe that it has to have the funding to do that so that planning is not treated simply as an afterthought.

Finally, we strongly support a regional biomass program that would allow the program of BPA in the Pacific Northwest to be extended to other regions of the country with high near-term potential for the use of biomass, and particularly wood energy.

This is a total budget of $20.5 million. If one were to add to that the money that the administration recommended for the alcohol fuels and municipal waste work, it would be a total budget of $29.8 million. I believe that this is an appropriate level, in a time of budget stringency, given the R&D that needs doing and the payoff that can come to all of us from doing it.

I believe that complementing and supporting this kind of a budget, one needs a more positive attitude within the Department, and that is willing to exert positive leadership to move the money out into the field and into the research, so that the results can happen.

I think that the administration is beginning to understand that biomass and renewable energy is not a political issue but a significant technological challenge, and one which, if met successfully, will provide jobs and economic benefits to the entire Nation.

Thank you for your time and interest.

[The prepared statement of Dr. Levine follows:]

Testimony by Dr. Leslie S. Levine

on behalf of the

BIOMASS ENERGY RESEARCH ASSOCIATION

presented before the

House Committee on Science and Technology

March 15, 1983

Good morning. I am pleased to have the opportunity to address the House Science and Technology Committee. My name is Leslie Levine and I am here as the Vice President of the Biomass Energy Research Association, a non-profit education and scientific organization established to promote understanding of biomass energy, and the role of research and development in biomass' growth as a national energy resource. Our membership includes representation from universities, businesses and utilities. The goals of BERA are:

- to educate the general public, industry and public officials about the opportunities for a major energy supply derivable from the many biomass feedstocks abundant in our country;
- to identify and promote needed R&D to economically grow and harvest biomass feedstocks and to convert them into useful fuels and chemicals;
- to establish a technical information clearing house for biomass energy data and literature, accessible to researchers, potential users of biomass energy, and officials involved with formulating policies and R&D programs;
- to encourage efforts to sustain a reasonable, well balanced and consistent Federal R&D program in biomass energy.

In attempting to meet these goals, we cooperate with other organizations in the renewable energy field including groups such as the Renewable Fuels Association and the National Wood Energy Association who represent the more commercial parts of the biomass energy community.

My remarks today will begin with some general comments on Federal R&D policy in the broad area of renewable energy; turn to the more specific area of the needs and potential benefits of biomass energy R&D; and conclude with a set of recommendations for what we believe would constitute a base-level Federally-sponsored R&D program.

Chairman Fuqua's request that BERA testify today included a request for comments on the proper Federal role in solar or, as I prefer, renewable energy R&D. I welcome the opportunity to speak about this, as it is a subject which has concerned me greatly both while head of the Office of Renewable Technology at DOE and, since 1981, as an officer of BERA and Director of Advanced Technology at JAYCOR, a small high-technology consulting company. The policy of the Administration, as I understand it, is that the Federal government should support those R,D&D activities where one or another of the following conditions are met:

- The private sector is unlikely to invest because the benefits do not accrue directly enough to a given company. This would, for example, pertain to fairly basic research and development or to studies of the environmental impacts of new technologies. It would also pertain to generic sorts of activities such as maintenance of large test facilities or technology transfer and information programs, such as NASA has traditionally performed.
- The private sector is made up of so many small companies or users that no one company can justify or afford the necessary investment. This is the basis for traditional Federal R,D&D roles in many areas of agriculture and the biomedical sciences.
- The technical risk or cost of a given project or program is too large for even the largest of companies to make an adequate investment in the R,D&D. This is clearly the rationale for continued Federal investment in nuclear fission projects like the CRBR, and in fusion.
- There is significant public benefit to the successful completion of the R,D&D. This would clearly be the case for areas like military R&D where the Federal government is the end-user. However, it is also clearly in the public interest to have affordable food and energy, high medical standards, and a clean environment.

From my experience and some historical research on the subject, I am led to the conclusion that these are, by and large, sensible criteria. The Administration has performed a service in reintroducing an intellectual discipline in addressing these policy questions, as well as in reasserting the appropriate role of the private sector as the dominant force in the commercialization process.

Where I find myself differing from Administration policy is in the way in which these criteria are applied, and nowhere is that more objectionable than in the areas of renewable energy and conservation R&D. Numerous studies - and some of the best have come from Congress' own Office of Technology Assessment - have demonstrated convincingly that there is large potential national benefit to be expected from many of these technologies. Further, the R&D investments are - by the standards of many other programs - quite small. Moreover, for most of these technologies, there were no industrial groups nor, indeed, was there really a technology base when ERDA and DOE programs began in the mid-70s. History will record the Federal investments of the 70s in these programs as being farsighted in laying the groundwork for new technologies and new industries. Yet even today, for most of the renewable technologies, we find industries consisting of small and struggling companies and R&D activities abandoned unfinished by the Federal government.

This has happened, I believe, because the Administration decided, early on, either that these technologies are unimportant or that they are somehow inexorably linked to a political philosophy with which they disagree. I believe that both judgments are wrong. I am relieved that

Congressional groups such as this one appear to share my perception and I hope that the Administration is, at long last, also coming to that conclusion. In the renewable energy industries today, one sees many companies struggling to improve products, find market niches, and make sales. I believe that virtually none of them would ask for Federal subsidies or major investment. What they do need, however, is a supportive DOE program that concentrates on doing the long-term R&D, and on providing support for generic activities like testing, resource evaluations and technology transfer. DOE should reassume a positive leadership role in helping the private sector, in forging public-private cooperation, and in informing the technical community and the public of the state of renewable technology. None of this will cost the government very much in this time of concern over deficits - in fact, by supporting the industry in areas like export promotion, it can have significant positive benefits - but it will take a change in attitude. We look forward to it.

If I may turn now to the more specific subject of my testimony, I would like to speak briefly about biomass energy and the appropriate Federal role BERA believes needs to be performed. Biomass energy is an excellent case study for some of the comments that I made before regarding the need for a well-defined Federal support role. All this notwithstanding the fact that biomass is, far and away, the most widely used of the renewable energy technologies (with the exception of large hydropower dams - a limited and mature technology). Thus, in 1983 it is estimated that over 3% of the Nation's energy, an amount comparable to that from nuclear power, came from biomass. Most of this was in the direct burning of wood and wood wastes - much by the forest product industries themselves - with much smaller contributions from wood gasification, methane from anaerobic digestion, and ethanol from corn. Despite the relative importance of biomass energy, it has been relatively ignored by the public and policy makers alike. It was only last year, in fact, that the Energy Information Administration of DOE began to tabulate the use of biomass as part of its national energy statistics. The reason for this relative ignorance of biomass stems from its decentralized nature. The ultimate strength of biomass energy is the close proximity between resource and user, but this also means that the industry tends to be small, scattered and diversified. This pattern tends to discourage the development of strong and unified representation. We believe this is one of the roles that organizations like BERA can perform.

At the same time that the current importance of biomass is ignored, the very commercial success and favorable economics that some forms of biomass energy enjoy is used as an argument against a vigorous Federal R&D program; there are those who argue that no further R&D is needed or that there are more "deserving" technologies which have not achieved any widespread use. I believe that this assessment is incorrect. The studies that have been performed clearly show that there are a number of advanced technical areas in biomass energy where modest R&D investments will yield significant benefits which will complement but not displace the ongoing biomass activity. Thus, for example, in OTA's excellent study of biomass energy, they estimated that improved energy "grasses" - that is, perennial plants which a farmer could harvest periodically as a source of replenishable fuel - could produce as much as a quad of new energy by the year 2000. Yet, DOE is proposing that we spend nothing on R&D in this field. Another example is the aquatic plants which, like grasses, can be raised without competition with conventional crops. These high-yield aquatic crops, which could potentially produce a variety of different liquid and gaseous fuels at very high productivities, are recommended for a 50% budget cut in FY84. A final brief example of the need for biomass R&D stems from the observation that we are now in the throes of a revolution in biological techniques - what is collectively referred to as "genetic engineering." I have been personally involved over the past year in a study of the potential of genetic engineering for biomass energy. It is clear that the potential is great indeed - both for improving the productivities or other characteristics of the plants being grown, and for improving the efficiency of the conversion steps often needed to convert these feedstocks into fuels. It was also clear from that study, however, that much of this potential benefit will not be achieved without a vigorous Federal R&D program - but more on that in a moment.

Going beyond these few examples, various studies over the past few years have estimated that biomass energy could contribute as much as 10 or 15% to the Nation's energy supply by the year 2000. Perhaps 50% of this contribution depends on R&D advances to improve efficiencies or economics, or to develop whole new processes. Benefits of this scale are large indeed; if R&D can improve the characteristics of biomass energy to make such contributions, the biomass production of the solid, liquid and gaseous fuels will significantly reduce our need to import energy. A second benefit which we have begun to look seriously at is biomass energy's ability to provide increased security to the Nation. The inherently small-scale and dispersed nature of the resource, and the fuels that they can produce, make biomass an ideal backup for energy disruptions and national emergencies. A third benefit which has not been adequately studied is the potential of biomass energy to create jobs - particularly in rural areas where job creation traditionally has been a real problem.

For these benefits to occur does not require large Federal outlays, but it does require a vigorous Federal biomass energy program to develop the new technology and to disseminate information about its potential. In this context, it is instinctive to judge biomass energy by the Administration's criteria we discussed earlier for Federal R&D involvement.

- First, much of the R&D that the DOE biomass program has supported would not be supported by the private sector because it represents fairly generic or basic studies of biomass production or conversion, or supporting work focused, for example, on mitigating environmental side-effects from wood combustion or gasification. R&D on production is a special case because - even where it is fairly applied - the lack of a patentable position has traditionally impeded private investment. This has been why USDA has invested public funds over the years in the development of new or improved crops and trees.
- Second, the biomass energy industries today are basically the classic "atomized" industry such as agriculture or the biomedical profession, which cannot afford to make large R&D investment. There are some large oil companies involved in ethanol

production and, of course, many of the large forest product companies utilize their wood wastes for internal energy; by and large, however, the industry still consists of many small producers of biomass feedstock and of conversion equipment. A Federal program can be the difference between success and failure for such companies.

- The third criteria of technical risk is also valid for parts of the R&D program. Certainly advanced crops such as aquatics, fall into that category. Even in genetic engineering, where there has been large private investment, we have found a great reluctance to invest in biomass energy applications. This is not because they are seen as being more technically risky, but rather, because the payoff from higher-value products such as pharmaceuticals is seen as much more attractive to the individual companies. It is probably fair to say that no other renewable energy technology has the breadth and depth of long-range R&D challenges to compare with those of biomass. At the same time, these R&D challenges appear affordable. Unlike technologies such as the breeder reactor, we are talking here of individual project R&D costs of a few millions to tens of millions of dollars to bring technologies to the point where the private sector can accept the technical and economic uncertainties and make the necessary investment.

- The fourth criteria is related to the potential public benefit of R&D success. We have already described some of those benefits above. It is clear that successful development of biomass energy will be a major benefit to our Nation.

It certainly seems to BERA that, based on each of these criteria, biomass energy is a reasonable and appropriate candidate for Federal investment. Given all of this, the proposed Administration budget for FY1984 is a disappointment. Biomass traditionally has been underfunded even among the renewable technologies, given its potential benefits and the benefits of R&D investment. What we are seeing in this budget is an acceleration of that trend. The decline in proposed funding from current fiscal year levels has been covered over by combining the Biomass Energy program budget with requests for the Office of Alcohol Fuels and the Energy from Municipal Waste program. If one subtracts out those requests, then the proposal represents a 40% decrease from the R&D funding available in FY83 which was in turn reduced by about 40% from the previous year. The proposed funding level of $8,000,000 is insufficient to continue the valuable R&D activities underway. It is also entirely out of keeping with the nature and potential benefits of the technology, and with the relative cost and benefits from biomass R&D.

I will address the details of the budget and the individual technical programs in a moment, but first I would like to make a few more general comments. First, the proposed budget is unbalanced in favor of conversion technology R&D. Virtually all of the feedstock production R&D has been eliminated; this is a serious mistake. In most biomass energy systems, the feedstock cost represents a large fraction of the final fuel cost. In some of the advanced feedstocks such as Euphorbia or the aquatic plants, liquid fuels are actually produced by the biomass, and the conversion component will be even smaller. Moreover, all of our studies indicate that the biggest relative R&D gains - from the application of genetic engineering techniques, for example - will be in the production area. This R&D will not be done by the private sector or by USDA, which is focused on food and fiber issues, and needs continued DOE support.

A second comment is that the regional biomass program which Congress explicitly called for in the FY83 budget action, has been eliminated. BERA believes that this activity, modeled after the successful work conducted by BPA and TVA in recent years, is very important and should be continued. One of the great strengths of biomass energy is its regional nature; there are appropriate biomass resources, technologies, and end-use requirements in virtually every region of the Nation. It is appropriate that the government catalyze regional activity by providing small amounts of seed money for regional planning, resource and technology assessment, and for starting the development of regionally-based biomass industries. A final comment is that I will confine my budget comments to the traditional Biomass Energy program activities. The proposed Alcohol Fuels and EMW efforts should be addressed by groups that have been more involved with those programs.

BERA supports, for the Biomass Energy program activities above, the budget shown on the following pages.

RECOMMENDED FY1984 BIOMASS ENERGY TECHNOLOGY BUDGET

A. Biomass Feedstock Production Research $ 9,000,000.

1. Woody Biomass Feedstocks..................$ 4,000,000.

The research which was started in 1978 to increase yields of woody biomass feedstocks by factors of two to eight over conventional forest industry production rates must be continued so as not to lose the benefit of the investment to date. Baseline annual yields at the best of the existing experimental sites should be measured as a function of soil quality, fertilization, irrigation and cultivation techniques. Analyses and experiments must be conducted defining optimal growth rates of woody biomass. Continuing research is needed in species screening. tissue culturing, hybridization techniques, as well as exploring genetic engineering approaches to increasing yields and resistance to disease. Coordination with private non-energy work is important.

2. Herbaceous Species Feedstocks............$ 3,000,000.

Vigorous research must be started for high-yielding herbaceous and emergent/wetlands species crops, including grasses, canes, cattails, hydrocarbon oil-bearing species, etc., suitable for conversion to biomass fuels. Species screening and plant hybridization studies should be performed to identify highest-yield feedstocks growing on lands less likely to be used for conventional food and fiber production. Experimental plantings are needed at representative sites to identify the effects of soil, fertilization and other cultivation parameters. Genetic manipulation and engineering techniques for increasing yields must be explored. Analyses are needed to define conditions under which high yield crops can be obtained as well as to evaluate the possible environmental impacts of growing and harvesting herbaceous and emergent species for feedstock production.

3. Aquatic Species Feedstocks..............$2,000,000.

Very promising experiments to grow and harvest oil-bearing and other microalgae from saline and brackish waters must be continued and expanded to establish baseline oil yields and to identify operating conditions under which yields can be increased, including the effects of water composition, flow velocity, nutrients, types of algae, and methods of harvesting. Research is needed to identify new species of oil-bearing algae and other aquatic plants and initiate breeding and other genetic manipulation techniques to maximize yields. Research results must be analyzed and evaluated. Innovative conceptual designs of future microalgae production experiments must be developed.

B. Biomass Feedstock Conversion to Fuels $15,300,000

1. Thermochemical Conversion...............$6,700,000.

Fundamental studies of physical mechanisms, efficiency of gasification and direct combustion are needed. In addition, adequate funding is directed for instrumented operation, analysis, and evaluation of existing process research units with results documented in order to obtain a complete data base. Experiments should be initiated aimed at improving process efficiencies and reducing capital equipment costs, including identification of improved catalysts and improved reactor designs. Also, experiments should be conducted to define process conditions under which yields of petroleum substitutes from fast pyrolysis can be maximized.

2. Biochemical Conversion Research.........$8,600,000

A vigorous research program is needed to explore innovative physical, chemical, enzymatic and biological methods for the processing of biomass feedstocks to increase yields of fuels. Fundamental studies of biochemistry and physiology are needed to provide a base for further development. Laboratory-scale and process research unit experiments for the anaerobic digestion of cellulosic and agricultural residue feedstocks should be continued to explore and define improved digestor designs, pretreatments, micronutrients, extent of compaction and other operating parameters that result in greater production of biogas. Microorganisms must be identified which are capable of increasing biogas yields and explore their genetic improvement.

C. Environmental Studies and Analyses $1,000,000

The proper development of biomass energy requires a continuing level of attention to environmental issues. Of particular interest are studies of wood gasification emissions and harvesting strategies. In addition, the program must devote increased attention to long-range planning as was pointed out in a recent ERAB Report.

D. Regional Biomass Energy Activities $5,000,000

For FY'83, Congress appropriated $4,000,000 for establishing regional biomass energy programs, similar to the successful effort at the Bonneville Power Administration. In addition to providing support for activities at BPA and TVA, DOE was directed to identify other regions of the country (specifically Northeast, Southeast, Midwest, Southwest, and Far West) and develop a program to identify and plan for regionally appropriate biomass technologies. These programs should continue in FY'84. Regional biomass energy programs are directed to carry out a variety of activities related to technology transfer, industry support, matching local resources to particular conversion technologies, resource assessment and harvesting techniques.

TOTAL OPERATING BUDGET: $30,300,000.

Conclusion

The budget we have recommended comes to $20,500,000 in operating dollars in FY1984. In addition we would recommend $1,000,000 in capital equipment funds be provided. This budget is at the same level as Congress proposed for FY83 for the Biomass Energy program. Note that our proposal does not include $8,500,000 of funds requested by DOE for Alcohol Fuel Office programs or $800,000 for Energy from Municipal Waste activities.

We believe that what is proposed represents a no-frills technology-oriented budget with no funds for commercial activities or projects. It is a small fraction of the budgets being requested for other activities within the Department of Energy. We believe, given the potential of biomass for the future of this and other nations, it will be an exceptionally good Federal R&D investment and recommend it to you.

Thank you for your time and interest this afternoon.

Mr. **Fuqua.** Thank you.

Dr. Takahashi, we would appreciate hearing from you at this time.

STATEMENT OF DR. PATRICK K. TAKAHASHI, ASSOCIATE DIRECTOR, HAWAII NATURAL ENERGY INSTITUTE, UNIVERSITY OF HAWAII

Dr. **Takahashi.** Thank you, Mr. Chairman.

I am associate director of the Hawaii Natural Energy Institute and professor of engineering at the University of Hawaii.

Prior to the fall of last year, for a little more than 3 years, I was a special assistant on energy to U.S. Senator Spark Matsunaga. In my capacity as the Senator's aide, I was involved in the introduction and passage of the various ocean thermal energy conversion bills with which Senator Matsunaga was involved.

I welcome the opportunity to address your subcommittee, Mr. Chairman, for I enjoy the cooperative relationship I had with your staff and still enjoy the relationship.

You asked me to specifically address possible future directions for the Department of Energy's ocean energy systems program. At the outset, let me say that while I have many times in the past served as a constructive critic of the OTEC concept, I nevertheless continue to believe that research and development should be allowed to proceed, for we really do not know yet whether this option is a viable one or not.

The fact that at least one of the two consortia involved with the conceptual design is seeking financing indicates that the OTEC option is real. During the past 8 years, the Federal Government has spent approximately $200 million on ocean energy systems. We will not know this year, nor the next, whether OTEC will have any real long-term chance in the marketplace. Even if a financial package can be floated during the next couple of years, there will remain immense imponderables and uncertainties on the concept in general and components in specific.

I should add that every innovative energy alternative from insitu coal gasification to the various nuclear systems falls into this category, and to terminate the OTEC option without reasonably conclusive proof would be shortsighted.

There are many that sincerely feel that the ocean will someday furnish us with significant quantities of power, if not in the form of electricity, then certainly in products such as fertilizer, ammonia, methanol, and hydrogen. Now that we have been given a sort of reprieve by the oil glut, some of the fundamental work necessary to insure for a solid foundation can be stretched out at a reduced cost.

On the foreign front, OTEC interest remains high, even though there is now some hesitancy and confusion occasioned by the U.S. perceived deemphasis.

Mr. Chairman, I will summarize some of the aspects of my statement here, and the rest can be put in the record.

The current situation is such that the United States again appears to be losing leadership on a technology where we still are preeminent. The capacity and the case for OTEC as a renewable energy option has been made many times before this committee.

Suffice it to say that ocean energy is one of the very few global options that is available in sufficient quantity to make a significant impact on the amount of nonrenewable energy consumed in the world economy; can deliver baseload energy in an environmentally, socially, and politically acceptable fashion; and has a potential for cost effectiveness in a wide variety of sizes.

The Federal program has made great strides toward developing this potential in the past few years. Accomplishments have included demonstration of the technical feasibility of the processes and materials necessary for successful plants in an operating net power producing system such as mini-OTEC; solution of design and operating problems associated with large-scale heat exchanger systems operating in seawater; deployment and operation of large seaborne experiments which address equipment and construction technologies necessary for successful deployment of the concept; conceptual and engineering design development of practical powerplants in sufficient detail to permit investment decisions to proceed in the industrial sector; design and construction of a seacoast test facility at the Natural Energy Laboratory of Hawaii dedicated to long-term research in ocean energy; and, finally, definition and creation of legal and financial instruments which could facilitate commercialization of the technology.

While there has been significant progress in the development of OTEC to this date, the real promise appears to be in materials, processes, and concepts which are still in the research laboratory. While the technology has turned a corner and is able to offer industry an opportunity to consider the prospects of commercialization, it is the full development of the concept still at the research level which will permit the maximum utilization of the vast ocean energy resource.

This research, although exciting in its potential, involves significant risks, and its payoff is far enough in the future, that industry cannot be reasonably expected to finance its completion. Indeed, the knowledge that advanced concepts are under active research may encourage industry to take a more active and aggressive role in developing the technology defined to date. It is this advanced technology which I would like to describe and recommend as appropriate for Federal funding.

There are four areas of research which need special attention. They are: One, advanced power conversion techniques and systems; two, cost-effective ocean structures and materials; three, innovative applications of OTEC systems and products; and, four, environmental and oceanographic impacts.

I will leave the rest of the detail on these four areas of research for the record, Mr. Chairman.

To accomplish this needed research, the following budget is recommended for fiscal year 1984: $5 million for advanced power conversion techniques; $2 million for ocean structures and materials; $2 million for systems exploratory research; $1 million for environmental and oceanographic impacts; thus, the total of $10 million as a total budget for fiscal year 1984.

I might point out, Mr. Chairman, that Senator Spark Matsunaga, earlier this month, obtained agreement from the Senate Energy and Natural Resources Committee to consider continued funding for OTEC research in fiscal year 1984.

It should be noted that no dollars are being suggested for additional funding of the remaining program opportunity notice phases. While this recommendation would probably not be universally accepted by the OTEC community, early discussions with the members of the Ocean Energy Council, an industrial organization which represents the community, lead me to believe that, if asked, they would endorse the concept of continuing R&D programs to insure maintaining U.S. leadership of this technology.

While the details of the future year budgets will, to a great degree, be determined by advances in the technology, a further recommendation is for a stable $10 million annual budget for ocean energy systems in fiscal years 1985 to 1988.

In summary, then, as results in the Federal program have provided a technical base from which ocean energy technology is developing, uncovering research opportunities which offer significant long-range promise for the technology, a strong argument can be made to maintain a vigorous R&D program.

The advanced power conversion work presently ongoing should continue to be focused toward the design, construction, and operation of a full, advanced system experiment at the seacoast test facility. In addition, the potential for combining OTEC with geothermal, effluents in general, waste heat, or other low temperature heat sources should be evaluated through a conceptual definition of candidate systems and an analysis of performance and cost parameters.

And, finally, exploratory research which assesses the feasibility of OTEC application in the production of fuel, water, and mariculture products should be completed and used as the means for defining program research priorities.

Mr. Chairman, I thank you for providing me the opportunity to appear before your subcommittee today.

[The prepared statement of Dr. Takahashi follows:]

"A RECOMMENDATION FOR OTEC FUNDING FOR FISCAL 1984 AND BEYOND"

Testimony Presented Before

THE U.S. HOUSE SUBCOMMITTEE ON ENERGY DEVELOPMENT AND APPLICATIONS
ON THE DEPARTMENT OF ENERGY'S FISCAL YEAR 1984 AUTHORIZATIONS
FOR SOLAR ENERGY RESEARCH AND DEVELOPMENT PROGRAMS

by

Patrick K. Takahashi
Associate Director
Hawaii Natural Energy Institute
University of Hawaii

March 15, 1983

My name is Patrick Takahashi. I am Associate Director of the Hawaii Natural Energy Institute and Professor of Engineering at the University of Hawaii. Prior to the Fall of last year, for a little more than three years, I was the Special Assistant on Energy to U.S. Senator Spark Matsunaga. In my capacity as the Senator's aide, I was involved in the introduction and passage of the various ocean thermal energy conversion (OTEC) bills with which Senator Matsunaga was involved.

I welcome the opportunity to address your Subcommittee, Mr. Chairman, for I enjoyed the cooperative relationship I had with your staff, both during the halcyon days of generous budgets and the budgetary crunch which came in 1981. You asked me to specifically address possible future directions for the Department of Energy's ocean energy systems program, and at the outset, let me say that while I have many times in the past served as a constructive critic of the OTEC concept, I nevertheless continue to believe that research and development should be allowed to proceed, for we really don't know yet whether this option is a viable one or not. The fact that at least one of the two consortia involved with the conceptual design is seeking financing indicates that the OTEC option is real.

During the past eight years the Federal government has spent approximately $200 million on ocean energy systems. We will not know this year nor the next whether OTEC will have any real long-term chance in the marketplace. Even if a financial package can be floated during the next couple of years, there will remain immense inponderables and uncertainties on the concept in general and components in specific. I should add that every innovative energy alternative, from in-situ coal gasification to the various breeder reactor and fusion systems falls in this category, and to terminate the OTEC option without reasonably conclusive proof, would be shortsighted. There are many that sincerely feel that the ocean will someday furnish us with significant quantities of power, if not in the form of electricity, then certainly in products such as fertilizer, ammonia, methanol, and hydrogen. Now that we have been given a sort of reprieve by the oil glut, some of the fundamental work necessary to insure for a solid foundation can be stretched out at a reduced cost.

On the foreign front, OTEC interest remains high, even though there is now some hesitancy and confusion occasioned by the United States' perceived de-emphasis. The Island Nations of the Kiribati, Nauru, and Papua New Guinea are eager to obtain some form of self-sufficiency through OTEC, or through a combination of OTEC and solar salt ponds. Similar political interest has been expressed and remains strong in the Marianas, Guam, Puerto Rico, and the Virgin Islands. The expectation has been heightened in Nauru where their "mini-OTEC" was technologically successful.

OTEC plants are under active developemnt by CNEXO of France for Tahiti and by the Netherlands for Indonesia. Taiwan has already constructed a solar pond power plant and is actively studying the possibility of an experimental OTEC or hybrid power plant.

Plans by Japan for an island self-sufficiency plant for an island in the vicinity of Okinawa appear to be still under development. Perhaps of greater importance are the embryonic developments which, if successful, will lead to major power developments in the form of electricity for a major industrial area, ammonia or hydrazine. Japan has already completed and is operating a bottoming cycle plant in Kyushu, which has survived a number of typhoons. Developments are well along in cold water pipe technology with a view to construction in Japan and with transport to a land or floating plant site. Consideration is also being now given to the construction of a grazing plant.

India is actively pursuing analytical studies with the long term view of producing ammonia or methanol. The initial studies are being carried out by the Oceanographic Institute in Goa and it is their intention to build a small experimental plant in the Southern Kerala area. Brazil has requested the use of OTEC-1 for its studies of the concept, and, I could add that a representative of the Soviet Union delivered a paper at the recent Pacific Science Congress in New Zealand, suggesting that OTEC was a U.S.-Japanese plot which would not work unless and until the Island Nations invited Soviet cooperation.

Thus, the frustration of the U.S. again losing leadership on a technology where we are today still pre-eminent. The case for OTEC as a renewable energy option has been made many times before this committee. Suffice it to say that ocean energy is one of very few global options that:

- is available in sufficient quantity to make a significant impact on the amount of non-renewable energy consumed in the world economy;
- can deliver baseload energy in an environmentally, socially, and politically acceptable fashion; and
- has a potential for cost effectiveness in a wide variety of sizes to match the application--powerplants from 1 MW to 1000 MW can be built.

The Federal program has made great strides toward developing this potential in the past few years. Accomplishments have included:

- demonstration of the technical feasibility of the processes and materials necessary for successful plants in an operating net power producing system experiment (mini-OTEC);
- solution of design and operating problems associated with large scale heat exchanger systems operating in seawater;
- deployment and operation of large sea borne experiments which address equipment and construction technologies necessary for successful development of the concept (OTEC-1);

- conceptual and engineering design development of practical powerplants in sufficient detail to permit investment decisions to proceed in the industrial sector;
- design and construction of a Seacoast Test Facility at the Natural Energy Laboratory of Hawaii (NELH) dedicated to long-term research in ocean energy; and
- definition and creation of legal and financial instruments which could facilitate commercialization of the technology.

While there has been significant progress in the development of OTEC to this date, the real promise appears to be in materials, processes, and concepts which are still in the research laboratory. While the technology has turned a corner and is able to offer industry an opportunity to consider the prospects of commercialization, it is the full development of the concept still at the research level which will permit the maximum utilization of the vast ocean energy resource. This research, although exiciting in its potential, involves significant risk and its payoff is far enough in the future that industry cannot be reasonably expected to finance its completion. Indeed, the knowledge that advanced concepts are under active research may encourage industry to take a more agressive role in developing the technology defined to date. It is this advanced technology which I would like to describe and recommend as appropriate for federal funding.

There are four areas of research which need special attention. They are: 1) Advanced Power Conversion Techniques and Systems, 2) Cost Effective Ocean Structures and Materials, 3) Innovative Applications of OTEC Systems and Products, and 4) Environmental and Oceanographic Impacts. I would like to speak briefly to each of the four research areas:

1. Advanced Power Conversion Techniques

Clearly the major opportunities for OTEC system innovation are in the power conversion systems. Despite the fact that OTEC closed-cycle systems, using the familiar Rankine cycle, are developed to the point of near implementation, large heat exchangers and the need to control corrosion and biofouling remain as disadvantages. The heat exchangers for the closed-cycle system represent about 30% of the plant cost. The program has come a long way from the expensive materials and biofouling control methods which characterized early heat exchangers, but further research is required to maximize the effectiveness of OTEC heat exchangers:

- to reduce the temperature loss in the equipment,
- through development of low cost heat exchange structures and materials with acceptable service life, and
- improved biofouling control which minimizes complexity, cost, and environmental impact.

The feasibility of several advanced thermodynamic cycles has been established. Of particular significance is the work that has been accomplished in open cycle OTEC. In this approach heat exchangers can be completely or partially eliminated along with the costs and temperature losses associated with them, and freshwater can be produced as a by-product. Significant advances on this technology have occurred just in the past year, but work remains on dealing with the fact that the seawater itself is used as the working fluid on the development of conversion hardware compatible with this medium. The construction, operation, and evaluation of an open cycle system experiment is required to resolve technical issues in this technology. The States of Florida and Hawaii are beginning to play a particularly important role in furthering the open cycle concept.

The scientific feasibility of other advanced power conversion concepts has been established on an analytical and laboratory scale experimental basis. Further assessment of the feasibility of geothermal and waste heat hybrid OTEC systems should be pursued. Basic research into the materials and processes which are necessary for the development of these ideas must be completed before their potential can be fully assessed.

2. Ocean Structures and Materials

A second area of critical importance to the cost and reliability of OTEC plants involves the structural elements of the system which must sustain operations in the ocean environment. The ocean platform, coldwater pipe, and mooring assemblies all have counterparts in the off-shore oil industry. However, in the case of the coldwater pipe the size of the structure demands new ideas in order to achieve system cost effectiveness. Research has yielded advancements on materials and deployment procedures for the coldwater pipe. This coming summer, an eight-foot diameter fiber reinforced plastic pipe will be deployed off the NELH on the island of Hawaii. Research is needed to evaluate the long-term properties of this structure in such an application. Deployment procedures which accommodate variable topographic and oceanographic conditions must be developed. Inspection, maintenance, and repair procedures to extend the useful life of the pipe are also necessary. The objective of this effort is to develop and evaluate a cost effective approach to bringing cold water to the OTEC power cycle.

3. System Exploratory Research

The ocean energy program has traditionally thought in terms of a power generation source feeding electricity into an onshore utility power grid. This has resulted in system concepts which are in the 100-400 MW_e size range and requirements for pilot plants of substantial size to allow scaling of experimental results with confidence. Recent research results show that there are viable applications of this technology over a range of system sizes and with a range of output products. An advanced OTEC plant can have multiple product (and therefore multiple income) streams. In sites where all the products can be used cost effectively, the minimum cost effective size plant may be smaller, thus making the investment required for pilot plant activity quite attractive, while still providing the technical data so critical to the investment community.

Exploratory research is needed to assess the feasibility of producing the following by-products in conjunction with OTEC operations:

- liquid and gaseous fuels,
- fresh water, and
- maricultural food products.

The ultimate benefit of the OTEC technology can arise out of the production of premium synthetic liquid fuel in an integrated coal gasification/OTEC enrichment plant or hydrogen from water. On the other hand, small plants which produce electricity, fresh water, and associated mariculture products may already be feasible for certain remote or island communities. Exploratory research which identifies the technology requirements for each application and establishes the commonality among them is required. In this way the technical approach which has the broadest application can be pursued through the research program and result in concepts with the best chance for ultimate full development.

4. Environmental and Oceanographic Impacts

Any technology research program should consider the impacts that successful implementation of the technology will have on the environment. In the case of OTEC we need to know more about the impact on:

- fisheries,
- operational toxicity,
- coastal zones, and
- the climate.

In addition, from the point of view of system performance, more knowledge is needed on the OTEC plant flow field (particularly recirculation concerns) and near plant physical interactions. This research would primarily be analytical, back with limited experiments so the community can better understand how OTEC affects the environment and how, in turn, it is affected by the environment.

To accomplish the above (1 through 4) the following budget is recommended for Fiscal Year 1984:

Advanced Power Conversion Techniques	$ 5 million
Ocean Structures and Materials	$ 2 million
Systems Exploratory Research	$ 2 million
Environmental and Oceanographic Impacts	$ 1 million
TOTAL BUDGET FOR FISCAL YEAR 1984	$10 million

I might point out that Senator Spark Matsunaga earlier this month obtained agreement from the Senate Energy and Natural Resources Committee to consider continued funding for OTEC research in Fiscal Year 1984.

It should be noted that no dollars are being suggested for additional funding of the remaining Program Opportunity Notice phases. While this recommendation would probably not be universally accepted by the OTEC community, early discussions with the members of the Ocean Energy Council, an industrial organization which represents the community, lead me to believe that if asked, they would endorse the concept of a continuing R&D program to insure for maintaining U.S. leadership of this technology. While the details of the future year budgets will to a great degree be determined by advances in the technology, a further recommendation is for a stable $10 million annual budget for ocean energy systems in Fiscal Years 1985 to 1988.

In summary, then, as results in the Federal program have provided a technical base from which ocean energy technology is developing, uncovering research opportunities which offer significant long range promise for the technology, a strong argument can be made to maintain a vigorous R&D program. The advanced power conversion work presently ongoing should continue to be focused toward the design, construction, and operation of a full, advanced system experiment at the Seacoast Test Facility. In addition, the potential for combining OTEC with geothermal, effluents, waste heat, or other low temperature heat sources should be evaluated through a conceptual definition of candidate systems and an analysis of performance and cost parameters. And finally, exploratory research which assesses the feasibility of OTEC application in the production of fuel, water, and mariculture products should be completed and used as the means for defining program research priorities.

Mr. Chairman, I thank you for providing me an opportunity to appear before your Subcommittee today.

PATRICK K. TAKAHASHI

EDUCATION

B.S., Chemical Engineering, Stanford University, 1962
M.S., Chemical Engineering, Louisiana State University, 1969
Ph.D., Chemical Engineering, Louisiana State University, 1971

PROFESSIONAL EXPERIENCE

1982–Present:	Professor, College of Engineering, University of Hawaii Associate Director, Hawaii Natural Energy Institute
1979–1982:	Special Assistant on Energy and Higher Education to United States Senator Spark Matsunaga
1978–1979:	Academic Assistant to the Chancellor, University of Hawaii
1976–1979:	Acting Associate Dean of Engineering, University of Hawaii
1975–1979:	Associate Professor of Engineering, University of Hawaii
1973–1979:	Research Associate with the Hawaii Geothermal Project and Hawaii Natural Energy Institute, University of Hawaii
1971–1975:	Assistant Professor of Engineering, University of Hawaii
1967:	Project Leader, computer applications, Hawaiian Sugar Planters' Association
1962–1966:	Process Engineer, C. Brewer & Co., Ltd.

PROFESSIONAL CONSULTANTSHIPS (selected)

1977–1979:	Lawrence Livermore Laboratory: Computer modeling of energy systems
1976:	National Aeronautics and Space Administration: Extrasolar planetary detection
1975:	C. Brewer & Company: Biomass applications
1974:	National Aeronautics and Space Administration: Planetary Resource Management
1973:	Lawrence Livermore Laboratory: Laser and energy applications
1972:	Sunn, Low, Tom and Hara (now M&E Pacific): Environmental engineering applications

PROFESSIONAL SOCIETIES

Chairman of the National Committee on Alternative Energy Sources and Systems in fiscal '83–'84, American Society of Civil Engineers
Past Chairman (1981) of the Wind Division Board of Directors, American Solar Energy Society
Past President of the Chemical Engineering Society of Hawaii, American Institute of Chemical Engineers

CONGRESSIONAL ACTIVITIES

Special Assistant on Energy to U.S. Senator Spark Matsunaga, involved in introduction and passage of various measures dealing with ocean energy, windpower, geothermal energy, biomass, fusion, fossil fuels, advanced batteries, and deep seabed mining. I coordinated his activities on the Labor/Human Resources and Energy/Natural Resources Committees.

RESEARCH AND PUBLICATIONS

Awarded 18 research, academic and training grants from the National Science Foundation, Department of Energy (and predecessors), National Aeronautics and Space Administration, Department of Health, Education and Welfare, and State of Hawaii. Thirty publications on energy and laser applications.

On various editorial boards, including the Editorial Advisory Board of the American Solar Energy Society and am Associate Editor of the *Journal of Wind Energy*.

Mr. **Fuqua**. Thank you, sir.

Dr. Berge, please proceed with your testimony.

STATEMENT OF DR. CHARLES W. BERGE, EXECUTIVE VICE PRESIDENT, GRACE GEOTHERMAL CORP.

Dr. **Berge**. Mr. Chairman and members of the committee, my name is Bill Berge. I am executive vice president for Grace Geothermal Corp., a very small independent geothermal operator.

Let me express my appreciation for your invitation to address this committee on the subject of geothermal energy.

My comments today will be directed to the Department of Energy's geothermal portion of the budget for the fiscal year 1984.

I have observed the Federal geothermal program since about 1974 or 1975. At that time NASA, the AEC, and NSF were the major participants. This was before ERDA and DOE were established.

I watched the budget for the Division of Geothermal Energy grow to about $150 million in 1979, 1980, and 1981. The 1981 budget was later rescinded to about $100 million, and subsequent budgets for 1982, 1983, and 1984 were $69 million, $59 million, and now the proposal for about $13 million.

Unfortunately, many of the major oil companies who were taking up some of the slack in geothermal research are now evaluating or dropping their involvement in geothermal. Due to oil prices and interest rates, they are taking money out of long-range projects in favor of short-term payout.

Now that the geothermal budget is minimal and company research is down, it is essential that the budget is used as effectively as possible. For many years, the Division of Geothermal Energy has been funding studies in hot dry rock. When the budget was large and the hot dry rock expenditure small, perhaps it was permissible. Now, however, things are quite different. Hot dry rock is taking virtually a major portion of the geothermal budget.

In a recent meeting composed mostly of directors of the Geothermal Resources Council, the topic of needed DOE research was discussed. From this meeting, a consensus was reached on several items of research that needed to be done.

Because of the diversity of the people involved, including people from the powerplants, people from utilities, major developers of geothermal, no consensus could be reached on the priority of the items. However, all agreed that these were the high priority items.

I, myself, at that time asked if anyone thought that hot dry rock warranted further research, trying to do that without any bias involved. The unanimous feeling was that it should have been long since abandoned. No one in the industry could justify using over one-third of the geothermal budget for hot dry rock.

The list of research needs that were developed involved: Development of brine handling, processes, and related injection and waste disposal systems; continued work on the reduction of drilling costs and the enhancement of well completion techniques; studies in the area of reservoir fracture identification and delineation; studies of thermodynamic property measurements of binary fluids; development of advanced utilization systems to provide for the economic production of electrical power using lower temperature fluids; studies of powerplant cooling systems including water conditioning; continued studies of logging and log interpretation techniques and hardware development; additional research on upstream removal of H2S in steam and the removal of arsenic and boron in geothermal brines. Several also thought that the deep research well, perhaps in terms of 18,000 feet, could also add significant knowledge.

Mr. Chairman, members of the committee, I have tried to outline areas of needed research for the development of geothermal energy that in the future will be helpful in supplying the needed energy for this country.

Some of the research areas mentioned are combined in the fiscal year 1984 budget, but they are being deprived of funds by the $5 million being spent on hot dry rock.

I would be happy to answer any questions.

[The prepared statement of Dr. Berge follows:]

Statement of Dr. C.W. Berge
March 15, 1983
Before The
House Committee on Science and Technology

Mr. Chairman and Members of the Committee my name is Bill Berge. I am Executive Vice-President of Grace Geothermal Corporation, a very small independent geothermal operator. First, let me express my deep appreciation for your invitation to address this important committee on the subject of geothermal energy. Formerly, I was the Manager for Phillips Petroleum Company and have been actively involved in geothermal since 1970. I have participated in research and exploration in most of the geothermal areas in this country and have visited several overseas installations. I am involved in scientific and industrial associations concerning geothermal and have served as President of the Geothermal Resources Council and as the Resource Subcommittee Chairman for the former Geothermal Energy Advisory Committee to the Department of Energy. I have also authored several papers on geothermal exploration.

My comments today will be directed to the Department of Energy (DOE) budget for Fiscal Year 1984. I have observed the Federal Geothermal Program since 1975 when NASA and NSF were the major participants before the ERDA was established.

I watched the budget for the Division of Geothermal Energy grow to about $150 million in 1970, 80, and 81. The 1981 budget was rescinded to about 100 million and subsequent budgets for 1982, 83, and 84 were $69 million, $59 million and now the proposal is for about $13 million. Unfortunately many of the major oil companies who were taking up some of the slack in geothermal research are now evaluating or dropping their involvement in geothermal. Due to oil prices, and interest rates, they are taking money out of long-range projects in favor of short-term payout.

Now that the Geothermal Budget is minimal and company research is down it is essential that the budget is used as effectively as possible. For many years the Division of Geothermal Energy has been funding studies in Hot Dry Rock (HDR). When the budget was large and the HDR expenditure small, perhaps it was permissable. Now things are different. HDR is taking a major portion of the research budget.

In a recent meeting composed mostly of GRC directors the topic of "Needed DOE Research" was discussed. From this meeting a consensus was reached on nine items of research that needed to be done. Because of the diversity of the people involved, no consensus could be reached on the priority of the items.

However all agreed that these were the high priority items. I asked if anyone thought that Hot Dry Rock warranted further research. The unanimous feeling was that it should have been long since abandoned. No one in the industry can justify using over one-third of the geothermal budget for HDR.

The list of research needs is:

1. Development of brine handling, processes, and related injection and waste disposal techniques, e.g., the crystalizer clarifier, EFP system, etc.
2. Continued work on the reduction of drilling costs and the enhancement of well-completion techniques.
3. Studies in the area of reservoir fracture indentification and delineation.
4. Studies of themodynamic property measurements of binary fluids.
5. Development of advanced utilization systems to provide for the economic production of electrical power using lower-temperature fluids.
6. Studies of power-plant cooling systems including water conditioning .
7. Continued studies of logging and log-interpretation techniques and hardware development.
8. Additional research on upstream removal of H_2S in steam and the removal of arsenic and boron in geothermal brines.
9. Deep research well (18,000 ft) in Imperial County.

Mr. Chairman and Members of the Committee, I have tried to outline areas of needed research for the development of Geothermal energy that in the future will be helpful in supplying the needed energy for this country. Some of the research areas mentioned are combined in the Fiscal Year 1984 budget, but they are being deprived of funds by the $5 million dollars being spent on HDR. I will be happy to answer any questions. Thank you.

Mr. **Fuqua**. Thank you very much, Dr. Berge.

The geothermal budget has gone from about $150 million in 1980 to about $13.5 in the fiscal year 1984 that we have before us. What do you think is a justifiable budget for geothermal in fiscal year 1984?

Dr. **Berge**. If I were just to take a number, I would say maybe in the $20 million to maybe $25 million range.

Mr. **Fuqua**. And what activities do you think we ought to be pursuing? Where would your priorities be for the $20 million to $25 million you are talking about?

Dr. **Berge**. My priorities would be in those areas that I mentioned, specifically, to some extent, almost environmental issues, if you view environmental as putting the fluids back in the ground, if you view it in terms of hydrogen sulfide technology and reducing the hydrogen sulfide, taking it out of the steam so as not to use it, say, for air pollution; also, in terms of power generation technology.

The geothermal resource varies from one end on the steam, like we have at the geysers, where they are producing in excess of 1,000 megawatts, down to where you have fairly low temperatures. Of course, at the high end, it is a commercially viable project. At the low end—and that depends on where you define it—it is not. In fact, just down below the steam, it is not.

Mr. **Fuqua**. Would the OTEC engine cycle technology be of any value with the low-grade heat?

Dr. **Berge**. I am not that familiar with the OTEC technology, Mr. Chairman, to comment on that, I do not think.

Mr. **Fuqua**. Well, it works on a—maybe Dr. Takahashi can help us a little bit. It works on a low-grade heat source, extremely low-grade heat source.

Dr. **Takahashi**. Mr. Chairman, one of the recommended areas of future research was to combine the various cycles, and perhaps at the bottoming end, using the OTEC concept with binary fluids, to maximize the utilization of the energy. It is possible, under the right circumstances, to combine geothermal warm water with some of the cool waters from different other locations.

The economics are unknown at this point, but it has not been given enough attention, I do not think.

Mr. **Fuqua**. While we are on OTEC, what is your assessment of what the technological status is of the various elements of OTEC?

Dr. **Takahashi**. Mr. Chairman, the closed cycle concept has been looked at to a very high degree. Most of the $200 million went toward investigating much of that idea.

There is a more recent, in the sense of research, interest in open cycle. I understand that the State of Florida is soon to undertake a study using the open cycle concept.

One of the byproducts of the open cycle could be fresh water, which could be of interest to Florida and island economies.

One of the strong areas for emphasis in my statement is to take a very close look at the open cycle concept, because again, like in the case of combining with other effluents like nuclear power, for example, or geothermal energy—the idea of the ocean thermal energy conversion concept can be used in conjunction with other energy sources. I would think these two areas of open cycle, combination with other energy sources, and also a third of products, would be three areas worthy for further pursuit.

Mr. **Fuqua**. Do you mean like taking the trailing water from a nuclear plant or even an oil-fired plant?

Dr. **Takahashi**. Right, sir, as an example.

Mr. **Fuqua**. DOE is not utilizing that in any of their proposals, are they, for low-grade heat?

Dr. **Takahashi**. To my knowledge, they have deemphasized that portion of their research program.

Mr. **Fuqua**. Would you care to comment why you think they have? Is it a technical reason? Is it feasible? Or do we not know?

Dr. **Takahashi**. The answer is we really do not know, but if one had to make an off-the-cuff judgment, one would think that it would not be as economical because of the efficiencies involved. Every time you deal with an energy cycle that has a small temperature differential, the smaller it is, the more inefficient it is. Therefore, theoretically, the more uneconomical it could be.

On the other hand, there are some advantages to a concept such as OTEC because the fuel is free, for example, and we really do not know what is going to happen until the right kinds of research studies are completed.

Mr. **Fuqua**. We, in Florida, are very much interested in this because of the potential that we have and also the warm Gulf water that we have in an abundant supply.

Dr. Levine, do you think there has been a good balance between DOE's near-term and long-term conversion R&D programs as reflected in the 1984 budget?

Dr. **Levine**. No, sir. I believe that in past years there was an attempt to create such a balance, but over the last year or so, even what I would consider valid Federal near-term roles have been eliminated almost entirely in favor of a program focused entirely on long-term, high-risk R&D which, as I tried to say in my testimony, does not traditionally represent the only Federal role.

Certainly technologies associated, for example, with harvesting of wood, or with low-Btu gasification of wood, are near term; they are economically viable. What is lacking is the infrastructure, the information, the technology transfer, and those have simply been eliminated from the budget.

Mr. **Fuqua**. What activities do you think should be carried out at the proposed regional biomass centers, and where should they be located?

Dr. **Levine**. The two regional organizations that have functioned in the past are BPA or Bonneville Power Administration, in the Pacific Northwest, and TVA in the Southeast.

They have, in a sense, been ideal because they are Federal organizations with broad regional mandates. The question of where should the other ones be, how should they be organized, is a more complicated one.

It is my sense, in terms of where, that the two most obvious areas are the Northeast and the upper Midwest. That is because of the very large wood resources in those two regions and the kinds of climatic conditions and industry that would require the use of high levels of energy.

I would advocate that regional organization in those areas be done by a nonprofit organization that somehow pulled together the State Governors' offices, State energy offices, and could act in a reasonable way for the entire region.

As to what should be done, I believe that the primary emphasis should be on coordination, on information, on technology assessment. To a lesser extent, the regional groups should support specific projects, much as BPA has done in the Pacific Northwest, not projects that are going to cost a lot of money but projects where, for example, a small investment will get a feasibility study done, or where the first of the projects are likely to lead to second and third projects without any government role.

Mr. FUQUA. Let me ask you three, if you care to answer, what impact do you think the reduction in oil prices is going to have on the development of these technologies, biomass, OTEC, and geothermal?

Dr. TAKAHASHI. There is very little doubt in my mind, Mr. Chairman, that it will depress financial interest in these technologies.

The danger, of course, is that this glut, if you can call it that, could be temporary, and there could be a time, if not in the distant future——

Mr. FUQUA. You say it could be temporary. Don't you think it is temporary?

Dr. TAKAHASHI. It is temporary, I agree.

For us to get shortsighted and to look upon this as a future forever is something that is why we are here, I hope, to reinforce some of your thinking that these are the kinds of technologies that should be supported, because they are indigenous; we can begin to attain a sense of energy self-sufficiency; we can develop these various technologies; and now is the time. More than anything else, research support is needed when there are difficulties with the basic, fundamental idea as to whether we should proceed or not. My viewpoint is that we absolutely should.

Mr. FUQUA. Dr. Berge.

Dr. BERGE. Historically, low prices of oil replaced whale oil and coal and coal oil and virtually put us in a very, some thought, wonderful position a few years ago, and then when the price went up, everybody started screaming. What about all the other things we could do, and why had we neglected all these things?

Mr. FUQUA. Why didn't you do something previously?

Dr. BERGE. Yes, and our memory seems to be very short.

So here we see now a windfall, you might say, in a way, a little time to give us a little more time to bring on these alternate technologies. If we don't do it, I am afraid our memories will be too short.

Mr. FUQUA. Dr. Levine.

Dr. LEVINE. I think the situation in biomass is somewhat unique. You can go out in the Southeast and buy wood chips today at the order of $13 or $14 a green ton. If you simply do the calculations, that comes out to about $1.50, $1.70 a million Btu's. That is very cheap. That is cheaper than oil is likely to get. The only fuel we have that is clearly less expensive is coal. The barriers to the use of wood thus are not fundamentally economic; they are institutional—the lack of an infrastructure and such.

On the other side, the kinds of things that we recommend in terms of R&D are really long-term R&D efforts. I think they are simply not affected directly by oil costs.

Mr. FUQUA. I guess maybe I have been around here too long, and some people agree with that, but I still remember back when, prior to 1973 and then in 1978, when we started getting gas lines, but prior to 1978, in the 1973 embargo, and in 1974 when it was lifted, prices started to stabilize; they did increase some, but supply was very good and people became fat and happy and were very content with what was happening and felt like it was a conspiracy to raise the prices of oil, and there was nothing to worry about; and then in 1979, when the gas lines started, I remember people thumping you on the chest and saying, Why haven't you people been doing something? Why didn't you know this?

We find ourselves, I think, in a very parallel situation right today, with a glut or whatever it is, depressed oil prices in the world, and we are sitting around now eliminating the budget on alternative sources. It seems to me that while we have the chance now is when we should be accelerating, because it is only a fool's paradise that anyone would believe that this is something that is going to be a permanent situation. It is still so volatile and precarious that it kind of just bothers me greatly that we are not moving on rapidly, not only in this technology but in synthetic fuel development and the other types of technologies that we need so badly, solar and all the others, wind, conservation, and all the programs that we need.

Anyhow, so much for that.

Mrs. Schneider.

Mrs. SCHNEIDER. I would like to—what is the proper phrase—associate myself with the remarks of the chairman.

Dr. Levine, I just have a couple of short questions. You were mentioning the regional programs. I was wondering—you mentioned Bonneville and another one. Is there not already a planning program underway for the Northeast right now? Is that underway now?

Dr. LEVINE. The congressional language that accompanied the continuing resolution called for programs like that of Bonneville to be created in other regions of the country.

As far as I can determine, the Department of Energy has done nothing about making that happen yet.

Mrs. SCHNEIDER. And do you have any hint as to whether or not DOE has any intentions or if they are thinking of using those fiscal year 1983 moneys for that purpose? Do you have any insight into that?

Dr. LEVINE. I would hope that they would. I have not seen any direct signs that they are going to do it.

Mrs. SCHNEIDER. All right.

Do you happen to know who is making the program decisions on, for example, regional biomass at DOE?

Dr. LEVINE. I would assume that would go through the normal chain of command and be the responsibility of the Assistant Secretary?

Mrs. SCHNEIDER. Mr. Tribble.

Dr. LEVINE. Yes.

Mrs. **SCHNEIDER**. All right. That is all that I have, and I thank you very much, and I am late for a meeting, so I am going to dash out the door.

Thank you, Mr. Chairman.

Mr. **FUQUA**. Thank you very much, Dr. Levine, Dr. Takahashi, and Dr. Berge. Thank you very much for being here today.

The subcommittee will stand in adjournment.

[Whereupon, at 4:14 p.m., the subcommittee recessed, to reconvene at the call of the Chair.]

○